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MATHEMATICS

A CLASSIFICATION OF CONTINUOUS TRANSFORMATIONS OF A COMPLEX INTO A SPHERE. I*

By L. PONTRYAGIN

(Communicated by I. M. Vinogradow, Member of the Academy, 25. II. 1938)

Two continuous transformations f and g of a topological space R into an n-dimensional sphere S_n** are usually called equivalent if there exists a continuous deformation transforming f into g. Thus all continuous transformations of R into S_n can be divided into classes, each class consisting of equivalent transformations. The problem of determining these classes (for given R and n) is one of the most actual problems in topology. For the case when R is an n-dimensional complex K_n this problem was completely solved by Hopf. For the case when $R = K_r$, $r > n$, it is as yet far from being solved.

In this and some subsequent notes I shall publish my results concerning some particular cases of the problem. In particular, in the present paper I give a complete classification of continuous transformations of the sphere S_{n+1} into S_n (for $n = 2, 3, \ldots$).

Let us begin by establishing some general properties of transformations of a topological space into a sphere.

We shall say that two continuous transformations f and g of a space R into a sphere S_n coincide in an open set $V \subset S_n$ if

1) $f^{-1}(V) = g^{-1}(V) = U \subset R$;

2) for every $x \in U$ we have $f(x) = g(x)$.

We can announce now the following three propositions (A, B and C) the proof of which is immediate.

Proposition A. If two continuous transformations f and g of R into S_n coincide in a non-empty open set $V \subset S_n$, then these transformations are equivalent.

Proposition B. Let V be a spherical region in S_n, F is a closed subset of the normal space R, V' and F' are the boundaries of resp. V and F (in S_n and R), and f is a continuous transformation of F into $V + V'$ such that $f(F') \subset V'$. Then there exists a continuous transformation g of R into S_n coinciding with f in V.

Proposition C. Let f be a simplicial transformation of a complex K into the sphere S_n (which we suppose to be decomposed into simp-

* Theorems 2′ and 2″ have been reported on my behalf by S. Lefshetz at the International Mathematical Congress in Oslo, 1936.

** We distinguish between a «sphere» and a «full sphere». A k-dimensional sphere is the boundary of a $(k+1)$-dimensional full sphere.

lexes), V is an open n-dimensional simplex belonging to S_n and $U = f^{-1}(V)$. Then U is homeomorphic to the topological product of V and a certain complex P, i. e. we can correlate every point $z \in U$ with a pair (x, y), where $x \in V$, $y \in P$ so that if z corresponds to (x, y), then $f(z) = f(x, y) = x$. Besides, if K is a manifold, then P is also a manifold.

The three-dimensional sphere S_3 is homeomorphic to a group $\bar{S}_3$ of quaternions. Let H be a monoparametric connected subgroup of $\bar{S}_3$ and consider the topological space $\bar{S}_2$ of all right co-sets of H in $\bar{S}_3$. This space is homeomorphic to S_2. If we denote by $\bar{\varphi}(x)\,(x \in S_3)$ the co-set containing x, then $\bar{\varphi}$ is a continuous transformation of $\bar{S}_3$ into $\bar{S}_2$. The corresponding transformation of S_3 into S_2 we shall denote by φ.

We shall say that a transformation f of a complex K into S_n is homologic to zero, if the image of each n-dimensional cycle Z in K modulo m, where m is an arbitrary natural number, is the vanishing cycle in S_n, i. e. if $f(Z) = 0$.

Lemma. *Let f be a continuous transformation of a complex K into S_2. If f is homologic to zero, there exists a continuous transformation g of K into S_3 such that $f = \varphi g$, i. e. such that for every $x \in K$ we have*

$$f(x) = \varphi\,[g(x)].$$

The proof of this lemma is based on the proposition C and involves a rather complicated construction in which some special properties of the transformation φ are used.

Hurewicz has proved that two transformations g and h of K into S_3 are equivalent if and only if the transformations φg and φh (of K into S_2) are equivalent.

This theorem of Hurewicz together with the above lemma allow us to reduce the question of the classification of homologic to zero transformations of K into S_2 to the question of the classification of all continuous transformations of K into S_3. And hence we obtain easily the classification of continuous transformations of S_3 into S_2.

In fact let f be a simplicial transformation of S_3 into S_2. Take any two points a and b of S_2 which are interior to their corresponding simplexes. Then $f^{-1}(a)$ and $f^{-1}(b)$ are cycles in S_3. Hopf has shown that the looping coefficient $\nu(f)$ of these cycles is an invariant of the class of equivalent transformations. It may be proved that $\nu(f)$ is the only invariant of this class. In other words we have:

Theorem 1. *Two transformations f and g of S_3 into S_2 are equivalent if and only if $\nu(f) = \nu(g)$.*

We proceed now to the case $n \geqslant 3$.

Theorem 2′. *For $n \geqslant 3$ there exist not more than two classes of transformations of S_{n+1} into S_n.*

Proof. Let f be a simplicial transformation of S_{n+1} into S_n, V is an n-dimensional full sphere with the centre a lying in one of the simplexes of S_n, and let $U = f^{-1}(V)$. Then by proposition C, U can be represented as the topological product of V and a manifold P consisting of a finite number of (topological) circles *. Modifying f we can easily make P consist of a single circle. By a second deformation of f we can make the curve (a, P) a differentiable curve (lying in S_{n+1}), (V, y) (for any $y \in P$) a (metric) full sphere normal to (a, P) and the transformation f isometric on (V, y). Let g be another transformation of S_{n+1} into S_n; we can suppose g to be modified in the same manner as f. Besides, any two

* I. e., in our terminology, one-dimensional spheres.

circles in S_{n+1} being isotopic, we can suppose that for both transformations the (a, P) [and, consequently, the (V, y)] coincide. Further, since the transformations f and g transform every (V, y) into V isometrically, we have $f(x, y) = g[\psi_y(x), y]$, where ψ_y is a rotation of full sphere V. Thus, the comparison of the two transformations f and g has lead us to the family $\{\psi_y\}_{y \in P}$ of rotations of an n-dimensional full sphere where P is a (topological) circle (and ψ_y depends of y in a continuous manner). But since in the manifold of all rotations of an n-dimensional full sphere V $(n \geqslant 3)$ there are only two different homotopic types of circles, it follows that there exist at most two classes of transformations of S_{n+1} into S_n.

In order to be able to proceed further we need another general proposition.

Proposition D. Any continuous transformation of S_r into S_n can be approximated by an analytic transformation. If two analytic transformations of S_r into S_n are equivalent, there exists an analytic deformation of one into the other.

The proof is based upon the possibility of approximation of a function of several variables by polynomials.

Theorem 2''. *For $n \geqslant 3$ there exist at least two classes of transformations of S_{n+1} into S_n.*

Proof. Let f be an analytic transformation of S_{n+1} into S_n. Then there exists a point $a \in S_n$ such that the set $P = f^{-1}(a)$ consists of a finite number of simple closed analytic curves having no points in common. The number of these curves we denote by β. Now take at a n mutually orthogonal vectors $v_1, \ldots, v_n$ and a point $y \in P$. The transformation f correlates the system $v_1, \ldots, v_n$ to a system of linearly independent vectors $u_1, \ldots, u_n$ orthogonal to P. To these vectors we join a vector u_0 tangent to P at y. Thus, at every point $y \in P$ we have determined a system U_y of $n+1$ linearly independent vectors. Let us now take at each point $z \in S_{n+1}$ a certain system of $n+1$ linearly independent vectors. The manifold of all such systems we denote by M. It may be easily established that the one-dimensional Betti group of M is the cyclic group of order 2. Let Z be an one-dimensional cycle in M not homologous to zero. The set of all systems U_y $(y \in P)$ defines in M a cycle homologous (in M) to the cycle αZ where $\alpha = 0$ or 1. Let $\gamma \equiv \alpha + \beta \pmod 2$. It may be proved that if we deform the transformation f analytically, γ remains constant (mod 2); if β remains constant during the deformation our assertion is evident, because the deformation of U_y is then continuous; the critical moments of the deformation (when β changes its value) require a special (however, rather elementary) consideration.

To prove theorem 2'' it is now sufficient to construct two transformations for which the rests of γ to the modulus 2 have different values 0 and 1. This may be easily done with the aid of proposition B.

In the next note I shall give the classification of continuous transformations of S_{n+2} into S_n.

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MATHÉMATIQUES

UN THÉORÈME SUR LES SYSTÈMES DE FORMES LINÉAIRES

Par A. GROŠEV

(Présenté par I. M. Vinogradow, de l'Académie, le 28. II. 1938)

Le présent théorème est une généralisation d'un théorème métrique de M. A. Khintchine (1) sur l'approximation simultanée d'un système de nombres réels et d'un théorème de l'auteur (2) sur les formes linéaires.

Considérons r systèmes contenant chacun s nombres réels:

$$\theta_{i1}, \theta_{i2}, \ldots, \theta_{is} \qquad (i=1, 2, \ldots, r). \tag{1}$$

On cherche une loi métrique caractérisant le cas où les formes linéaires:

$$a_1\theta_{i1}+a_2\theta_{i2}+\ldots+a_s\theta_{is}-b_i \qquad (i=1, 2, \ldots, r),$$

peuvent devenir simultanément proches de zéro quand les variables:

$$a_1, \quad a_2, \ldots, a_s, \quad b_1, \quad b_2, \ldots, b_r,$$

ne prenant que des valeurs entières, croissent indéfiniment. Plus précisement on cherche la réponse à la question: quelles sont les conditions qu'il faut imposer à la fonction positive $\psi(t)$ de l'argument t pour que le système d'inégalités

$$|a_1\theta_{i1}+a_2\theta_{i2}+\ldots+a_s\theta_{is}-b_i|<\psi(n) \qquad (i=1, 2, \ldots, r), \tag{2}$$

où $n=\max|a_k|\,(k=1, 2, \ldots, s)$, possède une infinité de solutions en valeurs entières a_k, b_i presque partout, c'est-à-dire, presque en tous les points de l'espace $(\theta_{11}, \theta_{12}, \ldots, \theta_{rs})$ à rs dimensions?

La reponse est donnée par le

Théorème. *Soit* $\psi(t)$ *une fonction continue positive de l'argument positif* t telle que $t^s\{\psi(t)\}^r \to 0$ quand $t \to \infty$ et d'ailleurs $t^{s-1}\{\psi(t)\}^r$ est constamment décroissant. Alors, pour que le système d'inégalités (2) possède une infinité de solutions en valeurs entières $a_1, \ldots, a_s, b_1, \ldots, b_r$ pour presque tous les systèmes de nombres (1) il faut et il suffit que l'intégrale

$$\int^{\infty} t^{s-1}\{\psi(t)\}^r dt$$

soit divergente.

Pour la démonstration l'auteur se sert des méthodes qu'on trouvera dans les deux articles cités, mais la manière d'obtenir certaines évalua-

tions qui se trouve dans le second article est simplifiée et étendue au cas d'un nombre quelconque de formes. À savoir, dans le mémoire (2) il fallait évaluer le nombre d'intersections se trouvant dans le cube unitaire des hyperplans de la famille:

$$nx_1 + a_2x_2 + \ldots + a_sx_s - b = 0, \tag{3}$$

avec les hyperplans de la famille:

$$n'x_1 + a_2'x_2 + \ldots + a_s'x_s - b' = 0, \tag{4}$$

où n et n' sont deux entiers positifs fixes tandis que les autres paramètres a_i, a_i', b, b' prennent des valeurs entières positives vérifiant les conditions:

$$a_i \leqslant n, \quad a_i' \leqslant n', \quad (b, n) = 1, \quad (b', n') = 1.$$

On peut évaluer ce nombre de la manière suivante. En faisant une transformation orthogonale des variables $x_1, x_2, \ldots, x_s$, on réduit les équations (3) et (4) respectivement à la forme:

$$\alpha\xi_1 - b = 0 \quad \text{et} \quad \beta\xi_1 + \gamma\xi_2 - b' = 0.$$

Si $\gamma \neq 0$ la condition nécessaire pour l'intersection des plans (3) et (4) dans le cube unitaire est l'inégalité

$$\xi_1^2 + \xi_2^2 < c, \quad c = c(s) = \text{const.} \tag{5}$$

En exprimant ξ_1 et ξ_2 au moyen de α, β, γ et ces derniers au moyen des coefficients des équations (3) et (4), on obtient de (5) la condition nécessaire d'intersection:

$$(n'b - nb')^2 < c\gamma^2(n^2 + a_2^2 + \ldots + a_s^2).$$

Cette condition a la même forme que celle à laquelle on a réduit le cas où $\gamma = 0$ dans l'article (2).

Cette manière d'évaluer le nombre d'intersections s'étend facilement au cas d'un nombre quelconque de formes.

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LITTÉRATURE CITÉE

[1] A. Khintchine, Math. ZS., 24, 706 (1926). [2] A. Grošev, Bull. Acad. Sci. URSS, Série mathém. № 3, 427 (1937).

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PHYSIK

ABSORPTION VON ULTRASCHALLWELLEN IN ELEKTROLYTEN

Von P. BAŽULIN

(Vorgelegt von L. I. Mandelstamm, Mitglied der Akademie, d. 2. III. 1938)

In dieser Notiz werden vorläufige Messergebnisse über Absorption von Ultraschallwellen in elektrolytischen Lösungen in Abhängigkeit von der Frequenz und Konzentration mitgeteilt.

Das Messverfahren wurde schon in einer früheren Notiz angegeben(1).

In der Tabelle 1 sind die Messergebnisse für verschiedene Elektrolyten bei derselben Frequenz $\nu = 30\,500$ kHz zusammengefasst. Bezeichnungen:

M—Molekulargewicht der Kationen,

α—Absorptionskoeffizient für die Amplitude im cm^{-1},

γ—Konzentration der Lösung in Mol pro Litre Lösung,

$\Delta\alpha$—Differenz des experimentellen Wertes von α für den Elektrolyten und für reines Wasser.

Tabelle 1

№	Lösung	t°C	M	γ	α	$\frac{\alpha}{\nu^2} \cdot 10^{17}$	$\frac{\Delta\alpha}{\nu^2} \cdot 10^{17}$	$\frac{\Delta\alpha}{M\nu^2} \cdot 10^{19}$
1	KCl	24	39.1	1.00	0.11	27*	—	—
2	NaCl	18.5—19	23	0.98	0.25	27	—	—
3	KBr	16—17	39.1	1.00	0.26	28	—	—
4	$NaNO_3$	20	23	1.00	0.25	27	—	—
5	KNO_3	17	39.1	1.00	0.25	27	—	—
6	$AgNO_3$	19—20.5	107.9	0.94	0.29	31	—	—
7	$MgCl_2$	16—16.5	24.3	0.50	0.30	32	—	—
8	$SrCl_2$	17.5—18.5	87.6	0.43	0.29	31	—	—
9	$Cu(NO_3)_2$	19—20	63.6	0.50	0.33	35	7	11
10	$Cd(NO_3)_2$	18—19	112.4	0.50	0.34	37	9	8
11	$Pb(NO_3)_2$	18—19	207.2	0.50	0.46	49	21	10
12	$(NH_4)_2SO_4$	17—17.8	17.0	0.50	0.37	40	—	—
13	Na_2SO_4	17—18	23	0.50	0.49	53	—	—
14	K_2SO_4	17—17.5	39.1	0.50	0.39	42	—	—
15	$MgSO_4$	20—21	24.3	0.122	0.35	38	10	41
16	$MnSO_4$	21—23	54.9	0.125	0.53	57	29	53
17	$NiSO_4$	19—21	58.7	0.125	0.46	49	21	36
18	$CuSO_4$	20—22	63.6	0.125	0.53	57	29	46
19	$CdSO_4$	22—23.5	112.4	0.125	0.64	69	41	36

* $\nu = 20\,100$ kHz.

Der Mittelwert von $\frac{\alpha}{\nu^2}$ für zweifach destilliertes Wasser im Frequenzinterval 19 000—37 000 kHz ist $28 \cdot 10^{-17}$.

In der Tabelle 2 sind die Messergebnisse für die Abhängigkeit des Absorptionskoeffizienten von der Konzentration und Frequenz für die Lösungen von $MgSO_4$ zusammengefasst.

Tabelle 2

№	Frequenz in kHz	t°C	γ	α	$\frac{\alpha}{\nu^2} \cdot 10^{17}$	$\frac{\Delta\alpha}{\nu^2} \cdot 10^{17}$
1	36 990	20—22.5	0.061	0.46	34	6
2	30 550	21—24	0.061	0.29	31	3
3	20 670	19.5—20	0.061	0.13	30	2
1	36 990	21—21.7	0.122	0.54	40	12
2	30 550	20—21	0.122	0.35	38	10
3	24 010	22—23	0.122	0.19	33	5
4	20 670	22—23	0.122	0.14	33	5
1	36 990	20—21.8	0.183	0.61	45	17
2	30 550	19.8—20.5	0.183	0.39	42	14
3	20 640	22—22.8	0.183	0.17	40	12
1	30 550	20—21	0.243	0.44	47	19
2	20 670	22—23	0.243	0.19	45	17
3	17 340	23—24	0.243	0.14	47	19
1	30 550	21 —21.8	0.365	0.50	54	26
1	30 550	19—21	0.487	0.69	74	46
2	20 640	22.8	0.487	0.33	78	50
3	19 030	21.5—22	0.487	0.29	80	52
4	17 340	21	0.487	0.25	83	55
1	20 640	22.5	0.974	0.47	110	82
2	19 030	22	0.974	0.41	113	85
3	15 670	21.8	0.974	0.27	110	82
4	12 410	21.5	0.974	0.17	110	82

In der Tabelle 3 ist die Abhängigkeit des Absorptionskoeffizienten bei $MnSO_4$—$Al_2(SO_4)_3$ für die Frequenz $\nu = 30\,500$ kHz angegeben. Während der Messung ist die Temperatur von 21° bis 24° variiert.

Die angegebenen Messergebnisse für $MnSO_4$ zeigen, dass die Frequenzabhängigkeit von α in diesem Bereich angenähert einem quadratischen Gesetze folgt. Allerdings scheinen bei kleinen Konzentrationen systematische Abweichungen vorzukommen, doch ist es noch verfrüht zu beurteilen, ob dieser Resultat der Wirklichkeit entspricht.

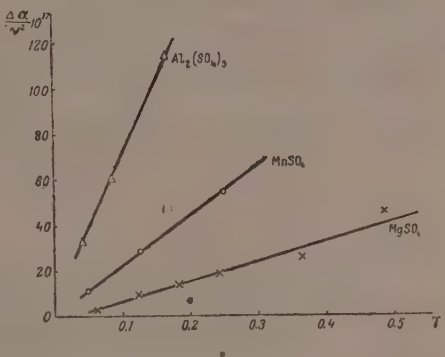
Die Tabellen 2—3 zeigen, dass die Grösse $\frac{\Delta\alpha}{\nu^2}$ ungefähr proportional der Konzentration ist. Dies ist gut aus der Fig. ersichtlich.

Tabelle 3

№	$\gamma \frac{\text{Mol}}{\text{Litre}}$	$MnSO_4$			$Al_2(SO_4)_3$		
		α	$\frac{\alpha}{\nu^2} \cdot 10^{17}$	$\frac{\Delta\alpha}{\nu^2} \cdot 10^{17}$	α	$\frac{\alpha}{\nu^2} \cdot 10^{17}$	$\frac{\Delta\alpha}{\nu^2} \cdot 10^{17}$
1	0.041	—	—	—	0.57	61	33
2	0.050	0.36	39	11	—	—	—
3	0.084	—	—	—	0.82	88	60
4	0.125	0.53	57	29	—	—	—
5	0.165	—	—	—	1.32	142	114
6	0.250	0.76	82	54	—	—	—

Die Messergebnisse der Tabelle 1 zeigen, dass für Salze mit einwertigen Kation und Anion, im betrachteten Frequenzinterval keine merkliche Abweichungen für die Grösse α im Vergleich mit Wasser beobachtet werden.

Beim Übergang zu ternären Elektrolyten mit zweiwertigen und einwertigen Kation und Anion (resp. Anion und Kation) wird α bedeutend grösser, als beim reinen Wasser. Bei binären Elektrolyten, auch bei sehr kleinen Konzentrationen wird noch eine stärkere Zunahme des Absorptionskoeffizienten beobachtet. Z. B. bei $CdSO_4$ für $\gamma = 0.125$ finden wir für $\frac{\alpha}{\nu^2}$ einen 2.5 Mal grösseren Wert als bei Wasser. Bei $Al_2(SO_4)_3$, dem dreiwertigen Aluminiumsalz, ist die Absorption noch grösser als bei $MgSO_4$.



Aus derselben Tabelle 1 ist ersichtlich, dass bei den Elektrolyten mit demselben Anion und derselben Konzentration der Absorptionskoeffizient α mit dem Molekulargewicht des Kations zunimmt. Ausnahmen bilden Sulfatsalze mit einwertigen Kationen (K_2SO_4, Na_2SO_4).

Wir können aus den erhaltenen Ergebnissen schliessen, dass bei Zunahme des Molekulargewichts des Kations und seiner Wertigkeit, die Grösse α zunimmt.

Es it augenblicklich verfrüht eine vollkommene Theorie der Erscheinung zu versuchen. Das Vorhandensein einer Abhängigkeit vom Molekulargewicht weist darauf hin, dass die Trägheit der Ionen bei ihrer Bewegung im Lösungsmittel eine Rolle spielt. Eine Theorie, welche diese Erscheinung bei Schallausbreitung in Emulsionen und Suspensionen berücksichtigt, ist von S. Rytow, V. Wladimirsky und M. Galanin(2) entwickelt worden. Die Anwendung der von ihnen abgeleiteten Formeln gibt bei Lösungen die richtige Grössenordnung für $\Delta\alpha$. Allerdings bleibt von diesem Standpunkt aus die Zunahme von α mit der Wertigkeit unverständlich. Es ist möglich, dass dies gedeutet werden kann, wenn wir die Debyesche Vorstellung heranziehen. Nach Debye ist in der Umgebung von Ionen, infolge der elektrostatischen Kräften, die Dichte des Lösungsmittels stark vergrössert (3). Da infolgedessen die mit

den Ionen mitgeschwungene Flüssigkeit eine grössere Dichte hat, muss auch die effektive Masse des Ions mit der Ladung zunehmen.

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CHEMISTRY

KINETICS OF THE FORMATION OF Mg_3Cd AND $MgCd_3$ FROM SOLID SOLUTIONS OF Mg—Cd ALLOYS

By I. I. KORNILOV

(Communicated by N. S. Kurnakov, Member of the Academy, 7. II. 1938)

1. In investigating the chemical transformation processes in a homogeneous medium (gas, liquid), the mechanism of the reaction is examined by studying the kinetics of the processes. As we know, the reactions mentioned obey the mass law, according to which their velocity at any moment is in proportion to the mass of the reacting substance.

For a monomolecular reaction the processes indicated may be expressed through the following equation:

$$\frac{dx}{dt} = K(a - x), \tag{1}$$

where a is the initial quantity of the substance, $a-x$, its quantity at the moment t, and K, the constant value of the velocity of the reaction.

The value K is determined by integrating equation (1) in the time interval, t_0 and t, of the reaction. It may be expressed as follows:

$$K = \frac{1}{t} \cdot \ln \frac{a}{a-x} = \frac{2.303}{t} \cdot \lg \frac{a}{a-x}. \tag{2}$$

The possibility of the direct chemical analysis of substances which are formed or which disappear during the reaction, or the study of changes in certain measurable physico-chemical properties, depending upon the duration of reaction, may offer a basis to the study of the kinetics of the reaction. The processes which take place in metals and alloys in the solid state may be studied by measuring the changes in the physico-chemical properties during reaction.

This method is used at present in studying the velocity of isothermic transformation processes of metals in a solid state. A number of authors [Fraenkel(1)] through a study of the velocity with which the chemical compound Al_2Zn_3 disintegrates, Bain (2), Wever(3) through a study of the velocity with which austenite turns into perlite etc., showed that the velocity of these processes agrees with the curve calculated theoretically by using equation(1).

There are changes known to take place in alloys of magnesium and cadmium, in which two chemical compounds Mg_3Cd and $MgCd_3$ are formed, and the MgCd is transformed polymorphically from one modification into another.

A study of the changes in electro-conductivity and partially in microstructure, which was made in previous works by N. I. Stepanov and S. A. Bulach(4)

and by N. I. Stepanov and the author of this paper ([5],[6],[7]), showed that the velocity of transformation in alloys of magnesium and cadmium depends upon the chemical composition. Chemical compounds have the greatest velocity, which decreases when one of the components is added in excess. Thus, in order to characterize the chemical nature of the system, the time of transformation was introduced into the equilibrium diagram. The works mentioned above, however, did not pay any special attention to the study of the very kinetics of the transformation processes. In this paper the author gives an account of work done in studying the kinetics of the formation of Mg_3Cd and $MgCd_3$ from solid solutions.

The change in volume of the alloys in the process of their transformation was chosen as the method of study. A description of the dilatometer, which was used by the author in studying the temperature of the polymorphic transformation of MgCd, was given in a previous paper([8]). This method, as used in the study of the transformation kinetics, is briefly as follows.

A sample of the alloy to be studied is put into the wide part of the glass dilatometer heated to a temperature above the transformation point and kept at this temperature until the alloy has been completely transformed.

After this the sample is quickly transferred together with the dilatometer to a thermostate with a selected constant temperature, in which the alloy will pass from an unstable state into a stable one. When the 3 minutes, necessary for the temperature to equalize, have passed after the transfer, a droplet of mercury is inserted in the capillary tube. This droplet serves as a stopper on the one hand, which keeps the air from penetrating into the dilatometer, and, at the same time, it shows the decrease in the volume of the sample during the transformation process.

By watching the movement of the mercury droplet along a millimeter scale in relation to time at a constant temperature we can study the kinetics of the transformation of the alloy according to the changes in the volume of the latter during this reaction.

2. The Kinetics of the Formation of Mg_3Cd. The investigations of Grube and Schiedt ([9]) proved that Mg_3Cd forms in a solid solution of magnesium and cadmium at a temperature of 150° and that a significant contraction in volume accompanies this formation.

In order to study the kinetics of the formation of this compound, the sample was heated to a temperature of 200° together with the dilatometer and was kept at this temperature until the Mg_3Cd had completely become a solid solution. After this the dilatometer was quickly transferred to a thermostat with a temperature of 100°, and after 3 minutes a droplet of mercury was inserted in the capillary tube of the dilatometer and then we began taking observations of the changes in its position in the capillary tube of the dilatometer according to time.

The volume of air in the dilatometer will contract as the volume of the sample decreases during the formation of Mg_3Cd from the solid solution.

The volume will evidently decrease in proportion with the mass of the substance which is being transformed, i. e. according to equation (1) of the kinetics of transformation, while the constant calculated after equation (2) will denote the velocity of transformation.

The results of the observations on the velocity of formation of the compounds are given in Table 1.

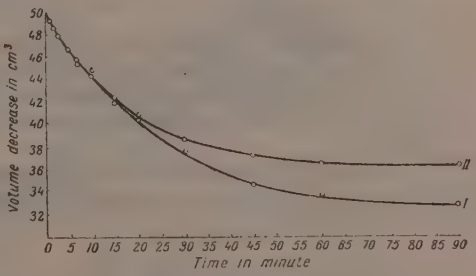
The time of observation in minutes is given in the first column; the reading of the dilatometer, in the second; $a-x$ is the difference between the reading of the dilatometer, at the time t and the final one, proportional to the transformed mass of the matter; K is the velocity constant of the reaction.

Table 1

Time in minutes	Reading of the dilatometer	$a-x$	$K=\frac{2.303}{t}\lg\frac{a}{a-x}$
0	50	18.7	—
1	49.3	18.0	0.0380
2	48.6	17.3	0.0388
3	48.0	16.7	0.0377
5	46.7	15.4	0.0388
7	45.6	14.3	0.0383
10	44.2	12.9	0.0371
15	42.0	10.7	0.0372
20	40.4	9.1	0.0360
30	37.6	6.3	0.0363
45	34.7	3.4	0.0379
60	33.4	2.1	0.0365
90	32.64	1.34	0.0370
120	31.3		
		K (average)	0.0375

The table shows that the decrease in volume is proportional to the duration of the reaction. The calculated velocity constant K does not show any marked deviation from its average (0.0375) while the compound is being formed.

The curve showing the decrease in volume during the formation of Mg_3Cd is given in the figure (curve I) and fully satisfies the kinetic monomolecular equation of the reaction.



Rate of formation of compounds Mg_3Cd (curve I) and $MgCd_3$ (curve II) from solid solutions.

Thus, the velocity of formation of Mg_3Cd from solid solutions is fully characterized by applying the kinetic equation of a monomolecular chemical reaction and makes it possible to calculate the change in quantity of the compound formed during the reaction.

3. The Kinetics of the Formation of $MgCd_3$. Just as in the case of Mg_3Cd, the formation of $MgCd_3$ at 90° is accompanied by a decrease in volume (9). This property was employed by us as a method of studying the kinetics of the formation of $MgCd_3$. A sample was heated to a temperature of 150° together with the dilatometer; after keeping the compound at this temperature until it had completely turned into a solid solution, the sample was cooled to 100°, and then quickly cooled with ice-water. Observation of the changes in position of the mercury droplet in the dilatometer at 0° was begun after 3 minutes.

The results of the study of the velocity of formation of $MgCd_3$ and the calculation of the constant K are given in Table 2.

The data in the table show that the value of K for various moments of the time t does not deviate greatly from the average value of the velocity constant, which equals 0.491.

Table 2

Time in minutes	Reading of the dilatometer	$a-x$	$K=\frac{2.303}{t}\lg\frac{a}{a-x}$
0	50	14.5	—
1	49.3	13.8	0.0495
2	48.65	13.15	0.0490
3	48.0	12.5	0.0495
5	46.8	11.3	0.0499
7	45.8	10.3	0.0489
10	44.3	8.8	0.0499
15	42.4	6.9	0.0495
20	40.9	5.4	0.0494
30	38.8	3.3	0.0494
45	37.1	1.6	0.0490
60	36.6	1.08	0.0491
90	36.45	0.95	0.0470
120	35.5		
		K (average)	0.0491

The corresponding curve of the decrease in volume during the formation of $MgCd_3$ is given in the graph (curve *II*) and it is fully analogous to the curve of a monomolecular reaction.

Conclusions

1. The changes in volume during the formation of Mg_3Cd and $MgCd_3$ from solid solution of magnesium and cadmium have been investigated.
2. Experimentally obtained data show that the velocity of the reaction of formation of these compounds is proportional to the mass of the transformed substance.
3. The velocity curves of the transformation of solid solutions into chemical compounds are well expressed in the kinetic equation of a monomolecular reaction.

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GEOLOGY

ON THE AGE OF THE VITIM BASALTS

By A. A. ARSENIEV

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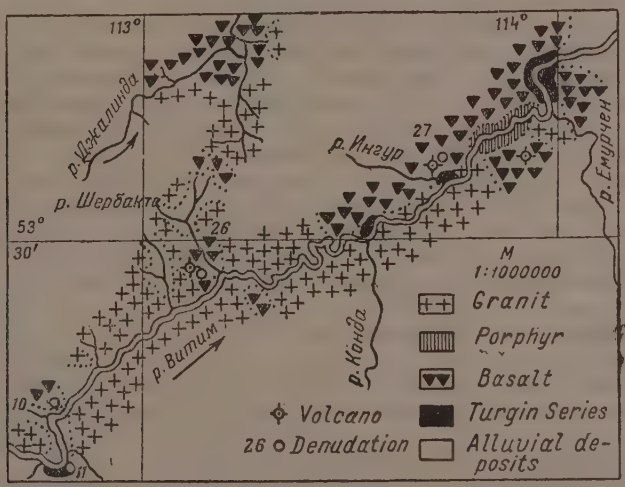
The area of the upper course of the Vitim river (the Vitim plateau), well-known by its outflows of basalt lava, has been studied by many explorers of Siberia ([1–6]).

The Vitim basalts were first discovered in 1898 by A. P. Gerassimov ([3,4]) who established their Quaternary age. In 1912 P. J. Preobrazhensky supplemented



Scheme of Vitim Basalts Distribution.

these observations, having described the Polivzevsky basalts (on the left bank of the Vitim river near the village Polivzevskoye) and the Sherbakta basalts (near the issue of the Sherbakta river) ([6]) and united these into a single Quaternary group.

In the regions adjoining the Vitim plateau basalts have been shown earlier by Kropotkin and Lopatin ([1–2]). A detailed description of Lopatin's collection has been made by Polenov ([7]), who discriminated the Dzhalindo-Amalat and the Zaza basalts.

Meister ([5]) has given some geological data, confirming the Quaternary age of the Dzhalindo-Amalat basalts. Two specimens of Quaternary basalt from

the Malyj Amalat valley have been briefly described by Polovinkina. Geological survey work in the Zaza district has been recently carried out by Ivanov who established the Lower-Cretaceous age of the Zaza basalts, having named these «paleobasalts» in contradistinction to the Quaternary basalts. Within the space available it is impossible to dwell in greater detail on previous investigations.

The author has studied the Vitim basalts over the area from the issue of the Kholoi river to the issue of the Ingur river. In comparing the Polivzevsky basalts (outcrop 10) with the basalts of the issue of the Sherbakta river (outcrop 26) and those of Mushketov volcano (outcrop 27, issue of the Ingur river), a difference has been detected between these, both in their geological occurrence and in their mineralogical composition in spite of their territorial proximity (see the map). For the sake of convenience, the name «paleobasalt» will be arbitrarily retained for the older basalts (until the analysis of the hole material has been finished).

Polivzevsky basalts: 1) Compact, less frequently vesicular, dark-brown and reddish-brown rocks, of a more ancient appearance as compared to other rocks. 2) No porphyry segregations are observed macroscopically. 3) The pores of the vesicular varieties of basalt are filled with opal, chalcedony, carbonate and chlorite. Empty amydgalae are rare. 4) The mode of occurrence of basalt is indistinct, it composes the hill on the left bank of the Vitim, about 70—80 m high, forming escarpments abruptly descending to the river. No contact with other country rocks has been observed. There are no clearly pronounced partings.

The Sherbakta and Ingur basalts (outcrops 26 and 27) are analogous: 1) Colour—black, less frequently brownish. Certain vesicular varieties (basalt slags) are reddish-brown. The appearance of the rock is perfectly fresh, extremely compact, sonorous. 2) Numerous porphyry phenocrysts of yellow-green transparent olivine, attaining 0.5 cm in diameter. 3) The pores of the vesicular varieties are empty. 4) Occurs in sheets. The thickness of the basalt sheet is from 15—20 m to 25—30 m. Columnar or banket structures, typical of basalt sheets, locally interbedded within the same outcrop are clearly pronounced. 5) The basalt sheet lies 30—50 m above the level of the river in different places overlying different rocks: metamorphic and massive-crystalline, as well as normal sedimentary ones up to Tertiary and Quaternary formations.

The petrographical characteristics of the basalts are also different.

Polivzevsky basalts (outcrop 10): porphyry rocks with phenocrysts of the same generation, represented by labrador № 60. In the peripheral part the phenocrysts occasionally contain small irregular inclusions of glass forming a border. The texture of the ground-mass is doleritic or intersertal in some varieties approaching the hyalopilitic.

The interstices between the irregularly distributed laths of plagioclase (№ 52—53) are occupied in the first case by small grains of augite and ore-minerals with a slight admixture of lamellae of brown biotite; in the second case, remains of glass, transformed to chlorite or a reddish-brown ferruginous mass, which exerts small effect on polarized light, are squeezed between the laths of plagioclase together with grains of augite and ore-minerals. The plagioclases are sometimes slightly zeolitized. Rare rounded amygdalae in the porous varieties are filled with brownish-green chlorite, opal and calcite in fine scales.

The young basalts (outcrop 26—27) are subdivided into two groups: 1) Porphyry basalts contain phenocrysts of two generations. The first generation is represented by large ($1^1/_2$—3 mm) single vitrified grains of fresh olivine, locally corroded by the ground-mass. The second generation is represent-

ed by considerably smaller (0.1—0.2 mm) and abundant crystals of olivine and brownish augite (the latter in subordinate quantities). The olivine of the second generation is more idiomorphous than the phenocrysts of the first generation, at the periphery its crystals are stained by iron oxide. The fine-grained ground-mass contains no glass and is composed of small laths of plagioclase (№ 60—65), irregular grains of violet-brown augite and magnetite. Ophitic texture (intergranular). Round empty pore-spaces constitute no more than 25% of the rock. 2) Basalt slag: empty round pores (2—3 mm in size) compose about 60—70% of the rock, giving it a slag-like appearance. Vitrophyric texture; the vitreous base is converted to an opaque or slightly-translucent reddish-black ferruginous mass, in which numerous plagioclase, olivine and augite microlites are irregularly disseminated. Intermediary varieties, whose structure approaches that the intersertal groups, are encountered.

All the young basalts are characterized by their perfect freshness. With the exception of a slight staining of certain grains of olivine by iron oxides, no post-magmatic alterations of the minerals have been observed. The phenocrysts belong to augite and olivine of two generations.

The «paleobasalts» are characterized by a complete absence of olivine. The phenocrysts consist only of labrador. A comparatively small number of amygdalae is filled with the above-mentioned minerals. Everywhere the glass is replaced by chlorite or a red-brown ferruginous mass. The general appearance of the rock is not fresh, strongly altered by post-magmatic processes.

In addition to the above facts, which are sufficient to establish the different age of the basalts, the author presents another proof confirming the pre-Lower-Cretaceous age of the Polivzevsky basalts.

Some eight kilometers upstream from the village Polivzevskoye in the escarpment of the right bank of the Vitim, outcrops of normal sedimental rocks, including boulders of «paleobasalts», have been discovered. The section of this series in ascending order is given below.

1. Close to the water an even-grained, brownish-grey sandstone, comparatively compact, calcareous is exposed. Apparent thickness 0.5 m.

2. The sandstone is overlain by friable coarse-grained conglomerates with more compact lenticular inclusions. The cement is calcareous. The conglomerate is filled with small and large (up to 0.5 m) slightly smoothed blocks of reddish-brown and brownish-black basalt with numerous amygdalae filled with chalcedony, calcite and chlorite. Thickness 3—4 m.

3. Friable, black, calcareous areno-argillaceous shales: thickness 0.1—0.2 m.

4. Compact calcareous sandstone, grey-coloured, upper portion even-grained, lower portion uneven-grained, with coaly sediments and impressions of plants. Thickness 0.35 m.

5. Friable areno-argillaceous calcareous shales, interbedded with sandstones and more compact arenaceous shales. Numerous bands and lenses of fibrous carbonate, up to 5—6 cm in thickness are encountered. Higher up they pass to bituminous oil shales with thin arenaceous seams. In the bituminous shales the numerous specimens of Ostracods* and Gastropods are accumulated; remains of woody matter are encountered. Total apparent thickness 8—10 m.

The whole series is slightly inclined to the south-east; angles of incidence from 15 to 20°.

In comparing the sediments just described to the well studied and faunistically characterized rocks occurring in the Vitim river valley ([4],[5],[8]), the Zaza

* A preliminary determination, made by E. G. Sharapova, of the Oil Institute, showed that they are similar to the Ostracods collected from analogous sediments in the Vitim valley in 1935.

valley ([1]) and other regions of Transbaikalia ([9]), the author comes to the conclusion about the synchronism of the bituminous oil shales with analogous sediments of the Turga series, whose fauna has been determined by Reiss, Egger([8]), Tschernyshev, and others*.

From this it will be seen that the age of the basalt from the conglomerate of the beds under description is referred to the pre-Turga time. A microscopic study shows: a porphyry rock with an intersertal structure of the ground mass, composed of plagioclase laths; the interstices between these are filled with brownish glass (almost completely replaced by chlorite), and with abundant small grains of the ore-mineral and augite. The phenocrysts, represented by prismatic crystals of the basic labrador, at places contain minute irregular inclusions of chloritized glass. The plagioclases are somewhat more intensely zeolitized than in the Polivzevsky basalts. Augite is replaced by fine-grained calcite with an admixture of epidote and chlorite. The amygdoid cavities are filled by calcite, colourless or brownish opal, and bordered by chlorite.

In comparing the mineralogical composition of the rock under description with the composition of the Polivzevsky basalts, the author has found a complete analogy between these. The somewhat greater development of the post-magmatic processes may be easily explained by the occurrence of basalts in the calcareous conglomerate in the form of boulders, which have been subjected naturally to a greater influence of the surface agents.

East-south-eastward in the same Zaza district, Lopatin([1]) and later on Ivanov have found that the Turga series lies on basalts and is partially interbedded with the latter in its lower horizons. For this reason Ivanov refers the age of the Zaza basalts to the pre-Turga time and regards them partially as synchronous to its lower portion.

Conclusions. In summing up the above geological and petrographical data the author comes to the conclusion that the basalts of the Vitim river valley belong to two different ages. 1. The Polivzevsky «paleobasalt» is doubtless older and should be referred to the pre-Turga time, being synchronous to the Zaza «paleobasalts» and the Vitim-Kansk which, according to Kotulsky ([10]), are overlain by Tertiary sediments. 2. The basalts of the central part of the Vitim plateau are referred to the Quaternary.

From this it should not be conclude, however, that the Quaternary basalts and the «paleobasalts» are strictly localized. Within the huge area of development of young basalts it is possible to find also more ancient basalts, and on the contrary, in regions with an extensive development of «paleobasalts» the presence of younger effusions is possible, which in turn may be referred to two or several phases of volcanism. The soluton of this interesting problem must be postponed until more detailed investigations have been carried out.

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* The majority of investigators refer the Turga series to the lower horizon of the Cretaceous. Less frequently it is synchronized with the American «Morrison formation» of the Upper Jurassic.

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STRATIGRAPHY

CONCERNING THE STRATIGRAPHY OF TERTIARY FORMATIONS IN THE SOUTH-WESTERN PART OF SOVIET SAKHALIN

By N. KOGAN

(Communicated by A. A. Borissiak, Member of the Academy, 8. III. 1938)

This paper is a result of the study of Tertiary mollusks collected by E. M. Smekhov in 1936 on the right shore of the Poronai River, in the region which on the north confines on the Daldagan River, on the south, with the Chyornaya River. The first description of the Tertiary formations in this region is due to A. N. Krishtofovich([1]), who divided them into two series: the marine and the coal-bearing one, without having established a well-defined relation of the two series to each other as well as to Cretaceous formations. The coal-bearing (Poronai) series is represented by sandstones, shales and seams of fine conglomerate. In the shales and sandstones flora is found, with *Sequoia Langsdorfii* (Brongn.), *Carpinus grandis* Unger, and others. The marine series consists of homogeneous sandy shales of vague slaty texture with huge lumpy concretions. It includes abundant remains of gastropoda and pelecypoda (e. g. the oyster). Paleontological and geological considerations lead A. N. Krishtofovich to the conclusion that the marine series is more ancient than the coal-bearing Poronai series, and that both of them very probably have their analogues in the littoral region of Western Sakhalin (the «gennoishi» series and the Upper Dui coal-bearing series).

In 1932 the same author ([3]) while studying the question of the Dui series of Western Sakhalin by the way expressed the supposition that Onor and Khandas coals may have been carried off to the Lower Dui series.

In 1936, in connection with prospecting for oil, the Tertiary formations of the Poronai region were explored in detail by E. M. Smekhov, who established the following sequence for the series ([5]) developed here (from bottom to top): 1. Khandas series. 2. Poronai coal-bearing series. 3. Onor series.

The beds of the Daldagan River (northern extremity of the region) which have as yet been associated with the above-mentioned series neither geologically nor paleontologically, constitute a separate group.

K h a n d a s S e r i e s. The Khandas series, tectonically unconformable to the subjacent Cretaceous sandy-shale strata of the Orokkian stage, is the most ancient of the Tertiary series known in this region. It is represented, according to Smekhov, by homogeneous dark-grey sandy and clayey aleurolites containing a large number of spherical or lumpy marlaceous concretions directed in the main along the rock strata. Thick strata of oil-bearing sandstones have been developed among the aleurolites. Beds of coal and conglomerate are met at the base of the series. The thickness of the series is about 900 m. Mollusks and scaled fish have been found in the shales and concretions. The author has determined the following species among the mollusks:

Acila (*Acila*) *gettysburgensis* (Reag.); *Chione* aff. *richthofeni* Hertl et Jond.; *Nucula* aff. *washingtonensis* Weaver; *Nuculana* sp.; *Palliolum* (*Delectopecten*) *pedroanus* (Trask) var. *peckhami* (Cabb.); *Thyasira smekhovi* n. sp.; *Yoldia chehalisensis* (Arn.); *Y. deformis* n. sp.; *Y. khandasensis* n. sp.; *Y.* cf. *longissima* Slod.; *Y.* cf. *packardi* (Clark); *Buccinus* sp.; *Margarites* sp.; *Natica* sp.; *Psephaea weaveri* (Tegl.); *Scaphander khandasensis* n. sp.; *Trichotropis* (?) sp.

Five of these species, whose determination is unquestionable, are widespread geographically and are known mainly from the Oligocene formations in the Pacific Basin. In particular the *Yoldia chehalisensis* (Arn.) is found in the Middle and Upper Oligocene of Western America (Lincoln and Blakeley series); *Psephaea weaveri* (Tegl.) in the Upper Oligocene Blakeley series of the Washington state; *Thyasira smekhovi* n. sp. is identical with the species of the Tigil series of Western Kamchatka (Paleogene); *Acila gettysburgensis* (Reag.) is found in America in deposits from the Upper Oligocene (Blakeley series, Twin River, and others) to the Middle Miocene (Astoria series, state of Washington), most often in the Upper Oligocene; and the *Palliolum pedroanus* var. *packhami* (Gabb.) from the Eocene (Tejon series, California) to the Middle Miocene.

Of the other species, the *Scaphander khandasensis* n. sp. greatly resembles and may, in the future, prove to be identical with the *S. washingtonensis gordoni* Tegl., a sub-species known from the Blakeley series of Washington state (Upper Oligocene). *Yoldia packardi* (Clark), with which I conventionally identify the Sakhalin specimen, is found in the Upper Oligocene formations of California and Washington; *Y. longissima* is known in Sakhalin and Kamchatka in formations from the Upper Oligocene to the Pliocene, and *Y. khandasensis* is perhaps identical with the species of the Pilsk series according to Schmidt's determination (Upper Oligocene).

The foregoing list thus shows the complete absence of species now living and a large number of either Oligocene species or species which, although having a wide vertical diffusion, are found in Oligocene formations too. This enables us to draw the conclusion that the Upper Oligocene age of the Khandas series is unquestionable. Comparing the fauna of the Khandas series with the fauna of other series of the Pacific Basin, we see its great similarity to the fauna of the Blakeley series of the Washington state. Of the 10 species given above, four (the *Acila gettysburgensis*, *Yoldia chehalisensis*, *Y. packardi* and *Psephaea weaveri*) are common to both series. If we add to them the *Scaphander khandasensis* n. sp. which, as stated above, closely resembles and is perhaps identical with *S. washingtonensis gordoni* Tegl., a species met in the Blakeley series, then the number of common species is equal to five, that is, 50 per cent of the entire number of species of mollusks in the Khandas series. The age of the Blakeley series is Upper Oligocene.

The question of correlating the Khandas series with series of the same age of Sakhalin and Kamchatka is much more difficult. The Pilsk series, according to Schmidt's determination, which has a certain lithological resemblance to rocks of the series under examination, has only two common forms: *Palliolum* (*Delectopecten*) *pedroanus* var. *peckhami*, and *Yoldia khandasensis*. Furthermore, the first species has a wide vertical diffusion, but the identity of the second species with a specimen from the formations according to Schmidt's determination is doubtful.

The same is true of the Kovachinsk series of Western Kamchatka, which has a lithological resemblance to both the Pilsk and Khandas series, but has only one form in common with the latter, namely *Palliolum* (*Delectopecten*) *pedroanus* var. *peckhami*, which, by reason of its wide vertical diffusion (Eocene-Middle Miocene) cannot be of help when correlating series geographically remote from each other.

The reason for such dissimilarity of faunas of the above-mentioned series, especially in view of the resemblance of mollusks of the Khandas series to the Blakeley series of America, is not clear. The facies of fauna may be somewhat different here. However, the reason may be the meagre investigation and incidental character of the collections of organic remains of the Kovachinsk and Pilsk series as contrasted with the Blakeley series which, according to N. Tegland ([5]), has about 60 species of gastropods and pelecypods.

The «gennoishi» series of the western shore of Sakhalin is lithologically similar to the Khandas series and, according to A. N. Krishtofovich([2]), contains small pelecypods and gastropods; remains of oysters have been found at the base of the series along the Agnevo River. A. N. Krishtofovich's collections from the «gennoishi» series have enabled me to determine two species: *Yoldia deformis* n. sp. and *Y. djakovi* Slod.

The meagre remains do not permit us to draw any conclusion at all concerning the age of the series: *Yoldia deformis* is a new species, as yet known only from the Khandas series and the «gennoishi» series, but the *Y. djakovi* is found in the Vayampolsk series of Kamchatka (Miocene). However, the fact that of two species so far known from the «gennoishi» series, one is common with the Khandas series, as well as A. N. Kristhofovich's discovery of oysters in the formations of the Khandas River* which, while relatively rare on Sakhalin, are also found in the lower «gennoishi» series along the Agnevo river—give certain ground though not a quite reliable one for drawing a parallel between the two series. This parallel is partly supported by the lithological similarity of the rocks, the closeness of the extension regions of both series and their overlapping by similar coal-bearing formations (Upper Dui and Poronai series).

From the aforesaid we may with a certain degree of probability put back the age of the «gennoishi» series from the Lower Oligocene, as assigned to it by A. N. Krishtofovich([4]) and I. P. Khomenko, to the Upper Oligocene.

P o r o n a i S e r i e s**. The Poronai series occurs conformably with the Khandas series. It is presented, after E. M. Smekhov, by dark quartz sandstones sometimes vanishing into conglomerates as they stretch on, dark-grey aleurolites, clayey shales with seams of carbonaceous shales and beds of coal. The shales and sandstones contain numerous imprints of plants, and at the base of the series indefinable nuclei of a fresh water species, the *Corbicula*, were found. The series is more than 1000 m thick. The stratigraphic occurrence of the series between the Upper Oligocene (Khandas series) and the conventionally determined Upper Miocene (Onor series, which will be analyzed below) enables us to consider the Poronai series as dating from the lower half of the Miocene.

If the supposition about the identity of the «gennoishi» and Khandas series is true, then the Poronai series corresponds to the Upper Dui coal-bearing series of the western shore of the island, and its age is then to be determined as the Lower Miocene (lower half of the Miocene).

O n o r S e r i e s. The Onor series occurs conformably with the Poronai series and is made up of grey sand-bearing clays with seams of glauconite

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* Unfortunately I had no opportunity to become acquainted with A. N. Krishtofovich's collections from the region of the Khandas and Onor rivers.

** The name «Poronai Series» introduced in 1927 by A. N. Krishtofovich and also used by E. M. Smekhov, is not a well-chosen one, inasmuch as it has long been used by Japanese geologists (H. Imai, H. Yabe, M. Yokayama, and others) for a part of the Tertiary strata of Hokkaido Island (Poronai Series, Poronai Beds, Poronai Shale), that is, for formations distinct from the Poronai series of Sakhalin. This causes a certain amount of confusion, to obviate which it would be well to give another name to the coal-bearing series of the region under investigation.

and conglomerate-like sandstones with lenses and pyrite concretions. Poorly preserved fauna of mollusks were found in the sandstones and clays. The latter also have a small number of foramin fers (*Cyclammina* and *Haplophragmoides*). The explored thickness of the series is about 600 m. Among the mollusks I have determined the following species: *Mya* ex gr. *arenaria* L.; *Nucula* aut *Acila* sp., *Nuculiana* (*Nuculana*) cf. *majamraphensis* (Khom.); *Tellina accedens* Böhm; *T. puchlensis* Slod. var. nov. (?); *Thyasira bisecta* (Conr.) var. alta Krisht.; *Th.* ex gr. *bisecta* (Conr.); *Yoldia* sp.; *Turritella* sp.

Of the above-mentioned species *Tellina accedens* is met in the Miocene (upper half of the Miocene?) of the Sakhalin formations; *Thyasira bisecta* var. alta, in the mellow series of Western Sakhalin (upper half of the Miocene) and in the Sawane series of Japan (upper half of the Pliocene); *Nuculana* cf. *majamraphensis* is conventionally identified with the species met in the upper parts of the Middle and in the Upper Miocene according to Schmidt's determination; finally a group of species which come close to the *Mya arenaria* L. and in which we also believe to belong our conches, is found from the Middle Miocene to the present day.

From the afore-mentioned the age of the series can be hypothetically determined as Miocene. Four species, of which two have been determined conditionally, are obviously insufficient for a more exact age to be assigned to the Onor series. However, we can, with a certain degree of probability, date the formation of these sediments from the upper half of the Miocene.

The Onor series very likely corresponds to one of the series overlapping the Upper Dui coal-bearing series of the littoral region of Western Sakhalin, that is, the mellow or Akhsai series with which it has three common species: *Thyasira bisecta* var. alta, *Tellina accedens*, and *Mya arenaria*.

Beds of the Daldagan River. The formations of the northern part of the region, which crop out in the valley of the Daldagan River, cannot as yet be linked with the above-mentioned series either geologically or paleontologically. They are presented at the base as a conglomerate which vanishes higher up into grey sandstones of average-sized grains, containing fauna of mollusks among which we were able to determine the following species: *Arca* (*Anadara*) *trilineata* Conr.; *Dosinia mathewsonii* Gabb.; *Mya* sp.; *Fusinus* sp.; *Natica* sp.; *Polinices* (*Neverita*) *reclusianus* (Desh.) var. *callosus* (Gabb.).

The three species about whose determination there is no doubt are: *Arca trilineata* which is found in formations from the Middle (?) Miocene to the Upper Pliocene; *Dosinia mathewsonii* from the Upper Oligocene to the lower parts of the Upper Miocene; *Policines reclusianus* var. *callosus* from the Upper Oligocene to the present time.

On the basis of these data the conclusion can be drawn that the age of the strata of the Daldagan River is possibly Upper Miocene; moreover, it may be possible to link them with the Onor series. However, the small number of species that have been determined, and also their wide vertical diffusion, two species dating from the Upper Oligocene being encountered, compel us as yet to leave the question of the age of these layers open.

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PETROGRAPHY

ON THE ULTRABASIC ROCKS OF EASTERN TRANSBAIKALIA

By I. V. LUCHIZKY

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At the time of geological route survey investigations in Eastern Transbaikalia guided by Prof. V. A. Obruchev, we find, among various igneous rocks of the country, dunites, picrites and serpentinites reported from the region Zhelezny Ridge([1], [2]).

Later data, however, on the occurrence of ultrabasic rocks in Eastern Transbaikalia are lacking. S. S. Smirnov ([3]) and E. A. Presniakov([4]), who have described olivine and pyroxene scarns from the region of Zhelezny Ridge, have not found there the above-mentioned rocks. The recent discovery of ultrabasic rocks on the Gazimur river is therefore of especial interest. This was made in the summer of 1937 in the course of research work carried by one of the Transbaikalian parties of the Geological Institute of the USSR Academy of Sciences, lead by E. V. Pavlovsky with the assistance of the present author.

Ultrabasic rocks, consisting of serpentinized peridotites and serpentinites, have been discovered by the above party in the neighbourhood of the Gazimur works, in the area of the right-hand bank of the Gazimur river. In this region the serpentinized peridotites and serpentinites form numerous dykes of a north-eastern strike, 1—2 m and more in thickness, and small stocks over 20 m in diameter, enclosed in a massif, composed of hornblende and pyroxene gabbro and gabbro-diorites, and partially of syenites. The massif stretches in a north-eastern direction from the Ildikan river in the south to the Uryumkanskaya Taina river in the north and is about 2 km wide.

The age of the ultrabasic rocks is evidently pre-Lower Jurassic. It is determined by the occurrence of basalt horizons of the marine Jurassic directly on the gabbro-syenite complex, to which the dykes and stocks of serpentinized peridotites are subordinate; this is clearly seen in the exposures along the right-hand bank of the Sredniaya river and the Kurochkina valley.

The age of the gabbro and, consequently, of the ultrabasic rocks is determined with sufficient accuracy, as the post-Lower Carboniferous, since in the Misturnaya valley the gabbro rocks show an active contact with the Carboniferous deposits, accompanied by a silicification of these deposits. Thus, the time of penetration of the gabbro and ultrabasic rocks is referred to the interval Carboniferous—Lower Jurassic.

1. Peridotite

Peridotite in a most fresh condition has been observed in a serpentinite dyke, at the right-hand bank of the Sredniaya river, near the issue of the

Uryumkanskaya Taina river. It presents a rock of a greenish-grey, almost black colour, composed (as it may be seen under a microscope) chiefly of olivine and hornblende. Spinal (pleonast) is also present in small quantities.

The quantitative proportion of olivine and hornblende is 70—75 per cent of olivine and 25—30 per cent of hornblende.

The structure of the rock is characterized by a clearly pronounced idiomorphism of olivine crystals, up to 2—2.5 mm in length, with hornblende grains of xenomorphic appearance, filling the interstices between the olivine crystals. In separate areas of the rock rather large grains of hornblende are observed, ingrowing poicilitic idiomorphous olivine crystals.

The olivine is colourless, transparent. Its constants $2V = +87°$ and $N_g - N_p = 0.039$ correspond to those of forsterite. A strong dispersion of optical bisectrices is observed.

Hornblende has a perfect cleavage along (110) with an angle 124° and an uneven colouring. It forms greenish grains with a hardly perceptible pleochroism, but separate portions of the same grain or individual grains are of a light-brown colour. In the latter case a clearly pronounced pleochroism is observed: along N_g—pinkish-brown; along N_m—light-green, almost colourless; along N_p—colourless; $N_g - N_p = 0.021$; $2V = -86°$; $C : N_g = 23°$.

It follows from these measurements that from its optical properties this hornblende closely approaches common hornblende.

Spinel (pleonast) is encountered in minute greenish grains and crystals of cubic syngony, enclosed in olivine and hornblende grains.

Apart from these minerals, a large quantity of serpentine (chiefly chrysotile) and magnetite, formed after olivine, is present in the rock.

The process of serpentinization begins at the periphery of the olivine grains, develops further along cleavage cracks and, finally, replaces the grain entirely.

At the same time a typical Maschenstruktur is developed. In the course of olivine serpentinization thin dendrites of magnetite are simultaneously isolated, being found most frequently in the middle of serpentinite bands.

Small quantities of chlorite and carbonate (magnesite) aggregates formed in the course of disintegration of hornblende are present in the rock.

The chemical analysis of the peridotite under description, according to the data of the Chemico-Analytical Laboratoty of the Geological Institute of the USSR Academy of Sciences (analyst A. A. Kazakova), is given below:

	Weight, %	Mol. quantities	
SiO_2	35.48	591	Magmatic formula according to Loewinson-Lessing: $10.7\,\overline{RO}.R_2O_3.6.9\,SiO_2$ $\alpha = 0.9$
TiO_2	0.17	3	
Al_2O_3	4.05	39	
Fe_2O_3	7.90	49	
FeO	3.17	44	
MgO+CaO	36.00	900*	
MnO	0.21	—	
Na_2O	not found	—	
K_2O	» »	—	
H_2O	0.74	—	
Loss on ignition	12.23	—	
P_2O_5	0.09	—	
Total	100.04	—	—

* Recalculated to MgO.

According to these data, the chemical and mineralogical composition of the rock corresponds to that of peridotites.

From the above chemico-mineralogical characteristics it follows that the peridotite from the neighbourhood of the Gazimur works is a peculiar representative of peridotites of the schriesheimite-cortlandite group, described by H. Rosenbusch([5]) from the valley of Schriesheim river in Odenwald, and described by Williams([6]) from the area of the Hudson river and some other places.

The peculiarity of the Gazimur peridotite consists in a high olivine content (70—75%) in the rock and in the absence of pyroxene in its composition. Owing to these peculiarities of the mineralogical composition of the Gazimur peridotite, it would be advisable to separate it as a singular representative of hornblende peridotites under the name of gazimurite.

2. Serpentinites

In different portions of the same peridotite dyke a passing of peridotite to serpentinite may be seen. In other dykes and stocks pure serpentinites, developed from peridotites, are usually of a dark-green, greyish-green or greenish-yellow colour, either more or less evenly coloured or party-coloured. Usually they are of a massive, less frequently schistose texture.

The structure of the parent rock may be distinguished in the structure of these rocks since in the pseudomorphs after olivine serpentine with typical Maschenstruktur is formed, the pseudomorphs themselves retaining the outlines of olivine crystals also in consequence of a corresponding distribution of magnetite dendrites. At the same time the portions of the rock composed of disintegrated hornblende consist of scales and fibres of chlorite and carbonate.

The serpentine is represented in this rock by finely fibrous chrysotile with a birefrigence up to 0.010 and a positive elongation.

Green spinel and carbonate is contained in these rocks as an impurity, the same as in peridotites.

The most altered varieties contain also phlogopite.

The above data make it possible to establish the presence of ultrabasic rocks in the Gazimur region, but in further investigations they induce us to approach carefully the problem of the origin of those serpentinites of Eastern Transbaikalia, which are described by the above-mentioned investigators as serpentinite of a contact metasomatic origin. The serpentinites of the right-hand bank of the Gazimur river, studied by the author, have been referred to the latter type also by M. V. Besova, as far as we can judge from the manuscript of her report.

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PETROGRAPHY

THE AVERAGE CHEMICAL COMPOSITION OF THE CAMBRIAN BASALTIC LAVAS OF WEST SIBERIA

By V. K. MONICH

(Communicated by A. E. Fersman, Member of the Academy, 10. III. 1938)

In the mountainous regions of West Siberia ([11]) some effusive formations of basaltic composition and belonging to the Cambrian deposits have been discerned by means of tectono-stratigraphical methods.

These volcanic formations play an important rôle in the geological texture of iron-ore and gold-bearing deposits, as Telbess, Abakan, Znamenity, Kommunar, Berikul, Central-mine, etc. Petrological and petrochemical investigation of the formations is still insufficient ([4], [7], [8], [10], [12]).

Having summarized all the materials which have been already obtained concerning this question, one comes to the conclusion, that the Cambrian basaltic lavas both in their separate species and in the whole are characterized by a number of peculiarities in the chemical and mineralogical composition; this distinguishes them from the effusive formations of other epochs; moreover, some regular changes in the composition according to age have been observed within the group of Cambrian effusives, and a petrochemical discrimination of eruptions of different ages seems thus to be possible.

The average chemical composition of the main Cambrian effusives displays their principal peculiarities which are still more conspicuous, if we compare the data of analysis with the average composition of the world-basalt, plato-basalt and melphyre (Table 1).

1. Chemical composition of the Cambrian basic effusives, average from 11 analyses ([4], [7], [8], [12]).
2. The Berikul porphyrites of the Martaiga Cambrian formation, average from 3 analyses([8]).
3. Plato-basalt, average from 43 analyses after Daly([2]).
4. Melaphyr, average from 11 analyses after Daly.
5. World-basalt, average from 198 analyses after Daly.
6. Devonian basic effusives, average from 6 analyses ([3],[7]).

To simplify the comparison magmatic coefficients and projection indices have been derived from the analyses of Table 1 after Loewinson-Lessing([5]) and Niggli systems ([9]).

In chemical respect the Cambrian basic effusives are peculiar basaltic rocks with following features of special importance:

1. High aluminium content ($al—alk+c$); in this connection the coefficient of $\overline{RO}$ and of SiO_2 in the formulae after F. Loewinson-Lessing is relatively small.

Table 1

The Average Chemical Composition of the Cambrian and Devonian Basaltic Lavas as Compared with that of the Related World Types

Oxides	Analyses					
	1	2	3	4	5	6
SiO_2	50.03	49.43	48.80	50.60	49.06	48.91
TiO_2	1.05	0.45	2.19	0.68	1.36	1.33
Al_2O_3	19.26	21.93	13.98	17.40	15.70	18.40
Fe_2O_3	4.08	2.41	3.59	4.57	5.38	3.87
FeO	6.52	7.03	9.78	6.29	6.37	6.28
MnO	0.30	0.19	0.17	0.46	0.31	0.16
MgO	4.05	3.04	6.70	4.89	6.17	5.97
CaO	6.92	8.27	9.38	8.09	8.95	6.78
Na_2O	3.39	3.26	2.59	3.23	3.11	3.26
K_2O	0.99	1.19	0.69	1.76	1.52	0.72
H_2O^+	2.98	2.29	1.80	1.83	1.62	2.69
H_2O^-	0.24	0.20	—	—	—	0.36
P_2O_5	0.15	0.14	0.33	0.20	0.45	—
S	0.09	0.19	—	—	—	CO_2=1.38
Total	100.05	99.72	100.0	100.0	100.0	100.11

Table 2

After F. Loewinson—Lessing

Analyses	Magmatic formula	Acid number	R_2O : RO
1	1.79 $\overline{RO}$. R_2O_3. 3.90 SiO_2	1.63	1 : 4.8
2	1.69 $\overline{RO}$. R_2O_3. 3.58 SiO_2	1.53	1 : 4.9
3	3.26 $\overline{RO}$. R_2O_3. 5.08 SiO_2	1.62	1 : 9.6
4	2.10 $\overline{RO}$. R_2O_3. 4.11 SiO_2	1.61	1 : 5.1
5	2.4 $\overline{RO}$. R_2O_3. 4.36 SiO_2	1.61	1 : 5.8
6	2.06 $\overline{RO}$. R_2O_3. 4.03 SiO_2	1.59	1 : 6.0

After P. Niggli

Analyses	*si*	*al*	*fm*	*c*	*alk*	*k*	*mg*
1	133.3	30.2	39.5	19.8	10.5	0.17	0.41
2	129.7	33.9	32.5	23.2	10.3	0.20	0.37
3	115.2	19.4	49.8	23.8	7.0	0.15	0.48
4	127.7	25.9	41.5	21.9	10.7	0.26	0.44
5	117.5	22.2	45.3	23.0	9.5	0.24	0.49
6	125.6	27.7	44.4	18.6	9.3	0.13	0.52

2. Somewhat reduced calcium content notwithstanding its significant rôle in the group RO.

3. Moderate content of alkali (far below $^2/_3$ *al*) of the sodium series only (k=0.17—0.20). The coefficients of Loewinson-Lessing make it possible to establish that the content of alkali is somewhat increased as compared to the oxide group RO (R_2O : RO$\approx$1 : 5).

4. Comparatively poor content of iron in particular and of femic group in general (*fm* up to 39.5), expressed in the typical decrease of the coefficient before $\overline{RO}$ and in the ratio $R_2O : RO$.

As to the more rare elements, there is observed a poor content of titanium in the magma and a considerable quantity of sulphur, combined in pyrite. The latter fact seems to be due to the metasomatosis of the rock mass which often includes ore-beds.

In the composition of the rock mass these peculiarities are expressed by a predominance of the leucocratic plagioclase porphyrites or hornblende porphyrites with the light-coloured uralitic hornblende, enriched by a molecule of sodium amphibole, and are characterized by transitions in the albite spilite porphyrites.

As to their chemical composition the Cambrian effusives of Siberia approach to the average type of melaphyres after Daly, differring from them, however, in the considerably higher content of alumina and lower content of ferro-magnesian portions.

A similar discrepancy is observed in the relation to the world-basalt composition.

The difference between the Cambrian effusives and the plato-basalts is much greater, their resemblance being reduced to the most general features only. In the latter case the most essential discrepancy of the rocks under investigation consists also in their magma being considerably rich in aluminium and poor in femic component.

Obviously all these features point to a peculiar type of chemism, inherent in the Cambrian basic effusives and expressed both in the principal formations (analyses 2) and even in their average chemical composition. Consequently this type of chemism acquires a leading petrographical and probably a correlative significance.

This may be shown, for instance, by inserting in the table above the average data on the chemical composition of the Siberian Devon basaltic lavas, which are the most similar to Cambrian formations compared from petrographical, chemical and structural viewpoints.

The resemblance between the Devon and Cambrian effusives is so great, that both were more than once confused by geologists.

A simple comparison of the analyses and especially of the magmatic coefficients and projection indices shows clearly that the Devon basaltic lavas have a pronounced different type of chemism, approaching to that of the world-basalt and plato-basalt (analyses 4—6).

As to the Cambrian effusives of Siberia the plagioclase basalts of Sakhalin and North-East Asia are their nearest analogs with regard to the composition ([1],[6]).

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BIOLOGY

THE SEASONAL CHARACTER OF THE RESPONSE OF FISH TO LOW TEMPERATURES

By P. J. SCHMIDT and G. P. PLATONOV

(Communicated by L. A. Orbeli, Member of the Academy, 8. III. 1938)

During our experiments of fish anabiosis and of its application to the transport of live fish (Schmidt and Platonov, 1936 and 1937) we came across a new phenomenon of an apparently great theoretical and practical importance, namely, the seasonal character of the response of fish to the action of low temperature.

The experiments, carried out on sturgeons in September, 1936, by G. P. Platonov at the Oranzhereiny Fish Factory, near Astrakhan, have shown that fishes, taken from the river at 17° and placed in a tank of water to which ice is gradually added for cooling, gradually loose their mobility and at about freezing point cease all respiratory movements, become immobile and look dead. When taken out of the water and placed on ice, the sturgeons preserve viability for 24—48 hours and on being transferred back into water revive and behave quite normally.

These results were likewise confirmed by the tests belonging to the series of our investigations of fish anabiosis carried on in 1937, on behalf of the Chief Fishery Department, at the Astrakhan Branch of Fish Curing of the All-Union Research Institute of Marine Fishery and Oceanography (VNIRO). In the beginning of November, 1937, N. A. Sokolovski, assistant of that Institute, carried out, in accordance with our instructions and after the methods applied by G. P. Platonov in 1936, a series of experiments with sturgeons at the Oranzhereiny Fish Factory. The results of those tests are summarized in Table 1.

As the data of the above table show, common and stellate sturgeons fall into a state of complete immobility at temperatures of from +0.5 to 0° and then, after storage on ice in an insulated box, placed in the corridor of a refrigerator with a temperature fluctuating between +3 and 0°, revive on being transferred to water.

N. A. Sokolovski also repeated the experiment of 1936, viz. he transported common and stellate sturgeons in a cooled state from Oranzhereiny Fish Factory to Astrakhan. On November 6 three young sturgeons (about 50 cm) and three stellate sturgeons were cooled down in 1 hour 40 min. to 0° in a tank with water and ice and then left in the water at 0° for 1 hour 40 min. more. After that they were packed in two boxes with ice and loaded into the hold of a refrigerator-barge, where the temperature was slightly above freezing point. The barge arrived at Astrakhan on November 7, where the boxes were kept for

Table 1

Experimental Cooling of Sturgeons in Autumn

Experiment №	1	2	3
Fishes	2 sturgeons 2 stellate sturgeons	2 sturgeons 2 stellate sturgeons	2 sturgeons 2 stellate sturgeons
Beginning and end of experiment	28.X—30.X	31.X—2.XI	2.XI—4.XI
Initial temperature of water before cooling	+ 10.0°	+ 10.0°	+ 10.0°
Final temperature	+ 0.2°	+ 0.0°	+ 0.5°
Duration of cooling	3 h. 10 m.	2 h.	2 h. 15 m.
Duration of storage on ice	45 h. 20 m.	28 h. 30 m.	45 h. 40 m.
Result	Revived	Revived	Revived

19 hours at +13° and for 9 h. 30 min. at +4.5°. During the loading of the boxes into the refrigerator-barge, one of them slipped and was overturned, so that the fishes in it were injured and bleeding. Only one of the sturgeons from this box manifested feeble signs of life when attempt of reviving was made. The common sturgeon and two stellate sturgeons, taken out of the other box on November 8 after a stay of 47 h. 30 m. on ice, were tied to a rope and placed in the river; they revived and were in a fully normal condition by the morning of November 9.

Several experiments made in the spring of 1937 showed that these fishes can likewise be cooled in spring-time to freezing point when they drop into an immobile state and that they can subsequently be revived after 1—2 days of storage on ice.

In view of the above observations the results obtained on cooling sturgeons, common and stellate, in July, 1937, were quite unexpected for us. These experiments were made by us on the wharf of Refrigerator No 1 of the Mikoian Fish Factory in Astrakhan. The fish, used in these tests, was kept in the live-fish perforated barge at the wharf in Balda river, in which the temperature not infrequently rose above +25°. The sturgeons and stellate sturgeons were either placed in a tank with water taken directly from the river and then gradually cooled with ice or were transferred to water priorly cooled to +7 or 6°. The results of these tests are given in Table 2.

The observations have shown that under the given conditions the sturgeons and stellate sturgeons cease all motion, including breathing, already at +3—2° and look dead. Cooled further to zero point and kept at that temperature for a time, they inevitably perish. When we had established this fact, we directed our experiments in such a manner, as to determine the lowest temperature, at which the fish still preserve viability. We, therefore, took the fishes out of the tank with a temperature +3—2° as soon as they ceased all motion. It was found that the sturgeons and stellate sturgeons, taken out of the water under the above conditions and transferred to warm water (they were usually returned to the live-fish barge), revive. It is very probable that if we could have stored these fishes at the temperature of +3—2° and with sufficient moisture and if we could have maintained such conditions without modifications for 24 hours or more, they would have also revived. Unfortunately the temperature of the refrigerator-chambers was much lower (—10° and lower), and we could not create the necessary conditions for the temperature in the box to remain at +3—2°.

Table 2

Experimental Cooling of Sturgeons in Summer

Experiment №	4/1	5/2	6/3	7/4
Fishes	1 sturgeon 1 stellate sturgeon (about 1 m)	2 sturgeons (about 90 cm)	1 sturgeon (about 90 cm)	1 sturgeon (about 75 cm)
Beginning of the experiment . .	13.VII 13 h. 30 m.	14.VII 10 h. 45 m.	17.VII 14 h. 45 m.	18.VII 13 h. 30 m.
Initial temperature of the water in the tank	+ 25.0°	+ 25.0°	+ 7.0°	+ 6.0°
Duration of cooling	2 h. 20 m.	3 h. 20 m.	35 m.	1 h.
Final temperature	+ 0.5°	+ 0.5°	+ 2.5°	+ 2.0°
Duration of storage in box with ice	24 h.	22 h.	19 h. 35 m.	24 h.
Temperature of the air in the corridor	+8.5—11.5°	+ 12.0°	+ 11.0°	—
Result . . .	Did not revive	Did not revive	Did not revive	Did not revive

The prohibition of fishing in the lower reaches of the Volga during June and July that was established in the summer of 1937 hindered us from being supplied by the nesessary quantity of live fish for our experiments and did not allow us to carry out a greater number of experiments, which would surely elucidate this problem in greater detail. In any case our experiments showed that in summer, when the sturgeons inhabit waters of a comparatively high temperature, cooling to zero temperature is lethal to them and that in such cases anabiosis sets in at the higher temperature of +3—2°. Thus, the response of fish to low temperatures depends on the season of the year.

Solitary observations and experiments with other fishes—carps, sheatfishes, tenches—made by us cursorily during the summer of 1937, have shown that this rule apparently spreads to them likewise; in summer they are much more sensitive to low temperatures, their anabiosis is much more difficult to produce and is of a shorter duration.

The experiments with young carps, 6—10 cm long, carried out by us under very primitive conditions in the end of July, 1937, at Astrakhan, present especial interest. The fishes were cooled directly in a laboratory beaker of 500 cm^3 volume by the addition of bits of ice to the water, the water being stirred with a thermometer. To protect the water from warming, the beaker was placed on ice or in cold water. It was observed that all external manifestation of life cease in the fishes at +5—6° and they look dead. On being taken out at that temperature and transferred to warm water, they soon revive. They can endure a temperature of +3 —2° for several minutes only, a longer stay at that temperature causes death. If they are transferred in a lifeless state to ice in a thermos bottle, they perish in a short time. We were not able to repeat our tests with them in autumn and winter; but it must be assumed that in these seasons, when they have to prepare for hibernation and to hibernate at very low temperatures, their response to cold is different. Probably, their response approaches the one observed by us in young crucian carps in Leningrad (Schmidt and Platonov, 1937, p. 255), which we preserved on ice in a thermos for a period of up to 10 days after cooling.

The seasonality established by us in respect of the response of fishes to low temperatures is a most essential factor as regards the direction of future studies of fish anabiosis, but it can also have a certain significance in piscicul-

ture. It shows that the response of fish to low temperatures must be studied in different seasons and that general conclusions cannot be drawn on the basis of observations and experiments conducted during any one season.

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GENETICS

CHROMOSOME MORPHOLOGY OF COTTON

By K. A. MIKHAILOVA

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Chromosome morphology plays an important part in the contemporary concepts of the phyletic relations between the species of *Gossypium*. However, there are several opposing views on the affinities of the three groups which form the genus *Gossypium*, viz., the group of the Old World (O. W.), the American group ($2n=26$) and the group of the New World (N. W.) ($2n=52$). In the main, there exist the following hypotheses. Davie [2] assumed that the N. W. cottons possessing $2\,n=52$ are tetraploids which originated from the O. W. cottons, the latter being in turn modified tetraploids with the basic number 7. In a later paper Davie [3] accepts the idea that cottons with $2\,n=52$ could originate from the American wild forms with $2\,n=26$. Arutiunova [12] approaches Davie in assuming that N. W. cottons represent tetraploid derived from O. W. cottons or, if they are amphidiploids, they should have originated from karyotypically closely related forms. This Arutiunova's conclusion is based on the assertion that the 52 chromosome-set of the N. W. cottons merely represents a duplicated set of the O. W. cottons. Skovsted [7], on the contrary, assumes that cottons with $2\,n=52$ are amphidiploids. One of the parental species probably was some O. W. cotton with $2\,n=26$ or a similar type, while the other should be closely related to the American species with $2\,n=26$.

The author based this hypothesis upon the results of investigation of chromosome morphology, as well as upon a series of other facts and speculations [8,9,10] [see also Webber[11]].

A large amount of data obtained by me [1] from a detailed study of chromosome morphology of the species of *Gossypium** makes it possible to throw some additional light upon the problem of the polyploid nature of the N. W. cottons with $2\,n=52$. The principal results of investigations** are presented below.

The caryotypes of the N. W. cottons with $2\,n=52$ (*G. hirsutum*, *barbadense*, *Hoppii*, *peruvianum*, *mexicanum*, *purpurescens*, *brasiliense*, *punc-*

* The root-tips were fixed mainly with La Cour's fixative and with the platinum and chrom-formol after Levitsky, in the first case staining with gentian-violet was used, in the second—iron-haematoxylin of Haidenhain. Chromosomes were measured by means of the «projection method» as worked out by Levitsky.

** Some of the results were communicated previously: a) Baranov and Mikhailova, Principal features of the Chromosome Morphology of Cotton [1]; b) read by I. D. Romanov before the conference at the All-Union Academy of Agricultural Sciences in January, 1935 [6].

tatum) are very similar to each other in general features, though the details are somewhat different in different species, and even in different varieties belonging to one and the same species. In the chromosome-sets of the species investigated by me there may above all be distinguished two chromosome groups: 13 pairs of larger chromosomes and 13 pairs of smaller ones [compare Skovsted (7)]. However, delimitation of these groups cannot be done with full clearness in contrast to Skovsted's results, since there always remain some chromosomes of intermediate size which are difficult to include with sufficient certainty into the one or the other group. There is, however, another character in which the chromosomes composing the set of N. W. cottons differ from each other: the chromosomes of smaller type always appear to be somewhat thinner than those belonging to the larger group. This character helps to distinguish the largest chromosomes of the smaller group from the smallest chromosomes of the larger group, though all may be similar in length. It should be noted that the difference in width appears to be a very delicate one and may be grasped only by judgment of eye; however, it is in any event more constant than secondary constrictions, a close study of which (1) convinced me that they are not constant. The fact that there exist in the chromosome-set cottons with $2n=52$ chromosomes, which differ in width, contradict the belief widespread over cytology that chromosomes of a given set should all possess the same width [Darlington(4)], as well the Navashin's data(5) on «neutral amphiplasty» in *Crepis* hybrids. However, maintenance of different width of chromosomes was observed in the hybrid set of *G. Sturtii*× *G. Davidsonii* [Skovsted(8)] and is verified by me in the hybrid *G. arboreum*× *G. trilobum*.

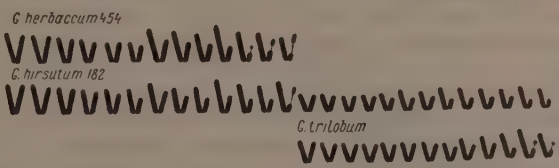
Very important is the fact that definite chromosome-types are represented in the chromosome-sets of cottons with $2n=52$ only by a single pair. Thus, from the idiogram of *G. hirsutum* № 182 ($2n=52$) (figure, middle line) it is evident that there is only one pair of chromosomes with large satellites on long threads; they belong to the group of larger chromosomes. In *G. Hoppii*, and in some other species (*G. hirsutum*, variety Navrotsky) as well, three pairs of satellited chromosomes are present in the set; however, they differ from each other in dimentions and in sizes of the satellites. Each type (*G. Hoppii*) or certain types (*G. hirsutum*, variety Navrotsky) of chromosomes are thus represented by a single pair in contradiction to the data of Arutiunova (12).

Upon detailed examination no fours of homologues can thus be found in chromosome-sets of the N. W. cottons. Such grouping may be done only approximately, but even in such a case a set not similar to that of *G. herbaceum*(12) will result. Amphidiploid character of the chromosome-set of the N. W. cottons is thus wholly evident. A more detailed study of the larger chromosomes has shown that they are very similar in size and in organization to those of the O. W. cottons [compare(7)]. The karyotypes of these cottons (*G. arboreum*, *Nanking*, *obtusifolium*, *herbaceum*) are similar in general features, though there exist some specific differences. As may be seen from the idiogram of *G. herbaceum* № 454 ($2n=26$), the set (figure, upper line) is composed of approximately 7 heterobrachial chromosomes and of 6 pairs of almost isobrachial ones. The latter (I—IV)* are characterized by a gradual diminution; the first three pairs (I—III) are the largest chromosomes in the whole set. The 7 pairs of heterobrachial chromosomes fall, approximately, into three groups. Two pairs (VII—VIII) of large chromosomes with a ratio of arms about $<2:1$; two pairs (IX—X) with a ratio about $>2:1$, and three pairs (XI, XII, XIII) markedly heterobrachial, the smaller arm being almost

* In each line of the figure chromosomes should be counted from the left to the right.

a knob and bearing a satellite. Two pairs (XII—XIII) are very typical of the chromosome-set of the O. W. cottons. The larger chromosome pair (XII) bears small satellites, while the smaller pair, on the contrary, has large satellites on very long threads. This latter pair is the smallest in the set (disregarding the length of the satellite). My results thus decidedly contradict the data presented by Arutiunova as regards the satellited chromosomes in *G. herbaceum*. There are three pairs of satellited chromosomes in *G. herbaceum*, while other species belonging to this group, for example, *G. obtusifolium* and *G. Nanking*, have only two pairs of satellited chromosomes, pair XI being the one lacking the satellites.

It may be seen from the comparison of the idiograms of *G. hirsutum* № 182 ($2n=52$) and *G. herbaceum* № 454 ($2n=26$) that the 13 pairs of larger chromosomes in the N. W. cottons are composed of the same 7 pairs of heterobrachial chromosomes and of the 6 pairs of almost isobrachial ones, similarly to the chromosome-sets of the O. W. cottons. Individual chromosomes of the sets of the O. W. cottons are different in certain details from the corresponding large chromosomes of the N. W. cottons. This may be particularly seen from the comparison of the idograms of *G. herbaceum* № 454 and *G. hirsutum* № 182 (figure). It is impossible to follow it up in detail here. I should emphasize only the importance of the lesser number of satellited chromosomes in the larger group as compared with the number present in the set of the O. W. cottons.



Idiograms of three *Gossypium* species. Upper line, *G. herbaceum*, № 454; middle line, *G. hirsutum*, № 182; lower line, *G. trilobum*.

G. barbadense, *peruvianum*, *hirsutum*, № 182, 0.100 and 1306 thus lack satellites in pairs XI and XII, and *G. Hoppii* has only a single pair XII. From the foregoing it is evident that the testimony of Davie ([2]) regarding the presence in diploid sets of *G. herbaceum* of one and in *G. hirsutum* of two pairs of considerably larger chromosomes is erroneous.

The remaining 13 chromosome pairs in the set of N. W. cottons are characterized, as it was already pointed out, by smaller size and reduced width. In this respect they are very similar to the chromosomes of the wild American species of *Gossypium* with $2n=26$, which was already pointed out by Skovsted ([7],[8],[9]). As the study has shown to us, the karyotypes of this group of species (*G. Harkuessii*, *armourianum*, *trilobum*, *Davidsonii*, *klotzchianum*) have small and somewhat thinner chromosomes than those of the O. W. cottons [compare also Skovsted([8])]. However, their set is to a certain extent similar to that of the O. W. cottons in localization of constrictions. As may be seen from the idiogram of *G. trilobum* (figure, lower line), the chromosome-set of this group of species is composed of approximately 6 pairs of heterobrachial chromosomes (VIII—XIII) and of 7 pairs of almost isobrachial ones (I—VII).

Among heterobrachial chromosomes three pairs (VIII—X) have a ratio of arms about $<2:1$ and three (XI—XIII) are markedly heterobrachial; one (*G. Harkuessii*, *klotzchianum*) or two (*G. trilobum*) of these have small proximal satellites.

As may be seen from the idiogram of *G. trilobum*, their satellited chromosomes are not the smallest in the set, in contrast to the situation in sets of the

O. W. cottons. In addition, the large satellites on long threads which are so typical of the latter are absent here. As regards the group of almost isobrachial chromosomes (I—VII), they are all of approximately equal size, as may be seen also from the idiogram of *G. trilobum*. Comparison of the chromosomes of *G. trilobum* with the smaller chromosome group of the N. W. cottons shows that they are similar not only in size, but to a considerable extent also in the localization of constrictions. The numbers of isobrachial and heterobrachial chromosomes are rather similar. As the investigation has shown, about 6 or 7 pairs of heterobrachial and an equal number of almost isobrachial chromosomes are present in the sets of the N. W. cottons (*G. peruvianum*, *barbadense*). There are present, further, only small proximal satellites in one of the heterobrachial chromosomes (*G. barbadense*, *peruvianum*, *Hoppii*, *hirsutum*, variety Shreder); it should be added that the satellited chromosomes are the smallest in the group. Full identity of these sets is, however, out of question, as there are many differences in details. The group of small chromosomes in the set of *G. hirsutum* № 182 is, for example, the one which is most different from the American cottons with 2 n=26, since this variety has more heterobrachial chromosomes and no satellited chromosomes at all. In *G. hirsutum* variety Navrotsky were observed two pairs of small heterobrachial chromosomes with large satellites on long threads. Such chromosomes are not present neither in other N. W. cottons, nor in wild American species with 2 n=26. The group of small chromosomes of the species *G. Barbadense*, *Hoppii*, *peruvianum* is more similar to the set of the wild American cottons with 2 n=26.

In summing up it should be emphasized that the amphidiploid nature of the chromosome-set of the N. W. cottons with 2 n=52 is wholly evident, but only with certain approximation one of the two sets which compose it may be identified with the set of the O. W. cottons, the other—with the set of the American cottons (2 n=26). The hypothesis of Skovsted on the origin of the N. W. cottons with 2 n=52, however, seems to me at present to be the most probable one, if considered from the cytological point of view.

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GENETICS

THE BLOOD COMPOSITION IN YAKS, IN CATTLE AND IN THEIR HYBRIDS IN CONNECTION WITH THE HETEROSIS OF THE HYBRIDS

By H. F. KUSHNER

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Hybridization of the local varieties of cattle with yaks produces hybrid progeny which is known to differ from each of the parental forms in increased live weight, better performance and larger dimensions. The heterosis is most pronounced in the first generation, and in further generations of crosses it gradually disappears.

In order to clear up the possible connection between the heterosis in these crosses and the blood composition of the original parental forms and of the hybrids, we have made determinations of the haemoglobine content, of the number of erythrocytes, of the size of the erythrocytes and of the blood alkalinity of the herd at the Oirat Zootechnical Station. Altogether 215 individuals (including youngs) of yaks, of cattle and of their hybrids were investigated. The analyses were conducted in the period between August 25 and September 12, 1937; each time blood was taken from the jugular vein in the morning before the animal was sent to grass. Haemoglobine was determined according to Sahli, the number of erythrocytes—in cameras of Thoma-Zeiss, the diameter of erythrocytes—in dry unstained smears by means of the ocular micrometer (magnification, $\times 2400$), and the blood alkalinity—according to Nevodov.

The results of the investigations are summarized in Table 1 (young) and in Table 2 (adult animals).

Without going into details of the age variation in blood indices, we shall point out only certain general regularities: the increase of the haemoglobine content with the age, the drop of the number of erythrocytes, the increase in blood alkalinity and the increase of the diameter of the erythrocytes.

As a specific peculiarity should be noted that the young yaks born in 1937 displayed strikingly low blood indices. It is difficult to say in what degree this phenomenon is regular since its interpretation is hindered by the fact that one of the two male parents was an yak (by name «Chort»), whose blood indices were repeatedly found to be two times lower than the normal ones (haemoglobine content 26 according to Sahli, number of the erythrocytes 2.8 million, blood alkalinity 310 mg%). Unfortunately the parental origin of the young yaks investigated by us was not recorded by the Station, but probably part of the young yaks born in 1937, if not all of them, were born to «Chort», and their low blood indices, might be, thus depend on the hereditary influence of their father.

Table 1

Blood Indices of the Young Yaks, Cattle and Hybrids

Age of the animals and blood indices	Yaks		Half-breed Simmentals F_1		Half-breed Simmentals F_2		Hybrids	
	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
Born in 1937								
n	6	1	8	4	12	9	7	4
Hb	36.8 ±3.95	50.4	51.7 ±1.47	51.5	51.4 ±0.9	49.3 ±2.5	51.7 ±2.06	54.05
R	6.415±0.70	7.64	8.6 ±0.24	9.21	9.53±0.375	9.84±0.25	8.3 ±0.35	8.61
Al	363.2 ±19	340	405 ±13.6	385	389 ±6.38	428 ±35	456 ±40.6	420
Di	5.55 ±0.122	5.89	5.39±0.06	5.27	5.34±0.07	5.32±0.05	5.43±0.06	5.3
Born in 1936								
n	—	—	4	—	6	—	11	5
Hb	—	—	50.4	—	53.35±1.209		50.0 ±0.4	52.3 ±1.37
R	—	—	8.05	—	8.72±0.5		7.79±0.296	8.6 ±0.17
Al	—	—	450	—	446 ±17.8		448 ±14.4	420 ±14.2
Di	—	—	5.44	—	5.43±0.053		5.6 ±0.084	5.22±0.008
Born in 1935								
n	6	5	18	—	3	—	3	—
Hb	53.3 ±2.22	52.4 ±0.99	54.9 ±0.72	—	57.83	—	52.96	—
R	6.22±0.22	6.53±0.51	7.25±0.20	—	8.11	—	8.19	—
Al	463.2 ±21.6	428 ±15.4	428 ±11	—	433	—	492	—
Di	6.05±0.13	5.59±0.107	5.82±0.07	—	5.75	—	5.64	—

Note 1. *n*—number of the animals in the group; *Hb*—haemoglobine content according to Sahli; *R*—number of erythrocytes in 1 mm³; in millions; *Al*—blood alkalinity in mg %; *Di*—diameter of the erythrocytes in microns.

Note 2. The statistical error for the diameter of the erythrocytes was calculated from the formula: $m_\Sigma = \sqrt{m_1^2 + m_2^2}$, where m_Σ is the total error; m_1, the error for the number of the erythrocytes measured in a smear; m_2, the error for the number of animals (smears) in the group.

Note 3. In hybrid animals the paternal origine is not always recorded. Together with the F_1, therefore, some individuals from the hybrids generations originating from back crosses could be included here.

Table 2

Blood Indices of Yaks, Cattle and Hybrids

Age of the animals and blood indices	Yaks ♀♀	Half-breed Simmentals F_1 ♀♀	Hybrids of yak with local cattle ♀♀	Hybrids of yak with local cattle ♂♂	Pure-breed Simmentals ♂♂	Local Siberian cows
Born in 1934 *n*	8	17	4	—	—	—
Hb	56.11 ± 2.41	52.0 ± 1.36	56.37 ± 2.71	—	—	—
R	6.23 ± 0.41	6.29± 0.017	7.325± 0.41	—	—	—
Al	487.4 ±16.2	456 ±12	505 ±10	—	—	—
Di	5.985± 0.09	5.97±0.06	5.85 ± 0.16	—	—	—
Born in 1933 *n*	4	12	—	—	—	—
Hb	61.05	50.74±5.51	—	—	—	—
R	6.78	6.36±0.25	—	—	—	—
Al	553.2	440 ±6.8	—	—	—	—
Di	6.11	5.88±0.06	—	—	—	—
Adult animals 5 years old and above *n*	13	6	21	4	3	14
Hb	58.9 ± 2.3	54.05± 2.32	64.73± 1.21	58.72	58.33	52.21± 1.07
R	6.20± 0.32	6.15± 0.4	7.38± 0.235	7.40	7.48	5.45± 0.21
Al	500 ±12	456.6 ±43	533.2 ±16.8	450	453.2	459.2 ±12.3
Di	6.09± 0.052	6.07± 0.058	6.08±0.052	5.82	5.59	6.12± 0.078

As regards the adult cows which have already completed their growth, specific differences and peculiarities of hybrids as expressed in blood indices are very characteristic. In haemoglobine content, in number of erythrocytes and in blood alkalinity, i. e. in the basic indices responsible for oxydizing power of the blood, hybrids greatly exceed the two parental species. The degree of these differences and their statistical significance are presented in Table 3.

The differences in the blood indices between the hybrids and the original species are thus not only great in absolute value, but their statistical significance is also highly probable.

Similarly increased blood indices, as compared with those of the parental species, were previously proved by us for hybrids between dromedaries and bactrians and for mules. All this allows us to conclude with greater certainty that better equippment of the blood of hybrids, higher oxydizing power per unit of blood volume are some of the immediate causes of the vigour of the hybrids as expressed in increased productivity, performance and hardiness.

The character of data which were gathered by us in the herd of the Oirat Zootechnical Station allowed also to decide upon the connection between the haemoglobine content and differences in weight within the group which were uniform with regard to breed and age. In Table 4 animals are grouped with regard to plus and minus deviation from the mean haemoglobine index for the given group, and live weights of the corresponding sub-groups are given.

Table 3

Significance of the Differences in the Composition of the Blood ($D \pm m_d$) between Hybrids and Original Species (Adult Cows)

Blood indices	Between hybrids and local Siberian cattle		Between hybrids and yaks	
	$D \pm m_d$	Probability in % of signific. of this difference	$D \pm m_d$	Probability in % of signific. of this difference
Haemoglobine content according to Sahli	12.52± 1.65	100	5.83± 2.6	97.5
Number of erythrocytes in millions	1.83± 0.31	100	1.18± 0.395	99.6
Alkalinity in mg %	74 ±21.0	100	33.2 ±20.6	90.0

Table 4

Differences in Live Weight in Connection with the Haemoglobine Content

Groups of animals	Local Siberian cows, $n=13$	Cows of yaks, $n=11$	Yaks of the first pregnancy, 3 years old, $n=6$	Half-breed Simmentals cows after first calf, 3 years old, $n=12$	Half-breed Simmentals born in 1935		Adult hybrid cows, $n=16$
					Their weight at the age of one year, $n=16$	Their weight at the age of one year and a half, $n=10$	
Plus variants in haemoglobine content	347.5	306.6	283	431.2	196	272.6	344
Minus variants in haemoglobine content	326	290.7	272.6	417	186.3	249.0	330.7

It may be concluded from Table 4 that the plus variants are in all cases also superior as regards their live weight. The results of our previous investigations on the blood composition of cattle at the Salsk Zootechnical Station, of sheep in Dagestan and of camels in south Kazakhstan were analogous: larger animals (when equally fed) possessed a blood richer in haemoglobine and erythrocytes.

The above said finds its physiological explanation in the fact that better oxidizing capacity of the blood causes a more intense metabolism and, accordingly, a more energetic growth of the organism. From the studies of Prof. Sbarsky it may be suggested, moreover, that larger surface of erythrocytes per unit of blood volume ensures better assimilation of food proteins and a rapid excretion of harmful toxines.

Analysis of the most important blood indices will thus undoubtedly facilitate judgment in estimating the constitution and breed-qualities of animals.

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GENETICS

THE CHEMICAL NATURE OF SUBSTANCES INDUCING POLYPLOIDY IN PLANTS

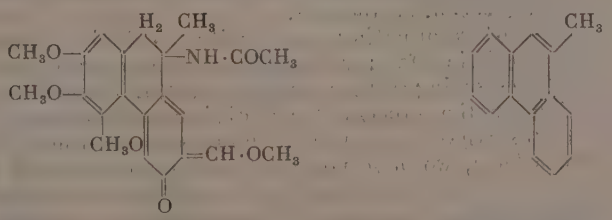
By A. SHMUCK

(Communicated by N. I. Vavilov, Member of the Academy, 29.III.1938)

In a very important paper published in 1937 A. Blakeslee and A. Avery have shown that the treatment of a number of plants with an alcoloid, called colchicine, results in inducing artificial polyploidy. This phenomenon has not only a theoretical significance, but also a very important practical one, since it can serve as a means of overcoming sterility of the hybrids, getting more vigorous and more productive plants, extending the geographical limits of the regions of their cultivation, etc.

Colchicine is found in *Colchicum autumnale*, *Gloriosa superba* and in some other plants and is one of the strongest plant poisons.

According to its chemical structure, established by A. Windaus, colchicine belongs to the group of alcoloids of the phenanthrene series.



Colchicine — Methyl-phenanthrene

It is known that morphine, codeine, tebaine, alcoloids of the coridaline series and those of the berberine one are also alcoloids belonging to the same phenanthrene series. But the structure of colchicine has a very important peculiarity, distinguishing it from the alcoloids mentioned above. This peculiarity consists in its having no heterocyclic nuclei and in its nitrogen lying in one of the side chains. From that point of view colchicine occupies a most singular position among the alcoloids of plants and can be classed among that group but with some strain.

This peculiar structure of colchicine, distinguishing it so sharply from other alcoloids, approximates it in the same time to another group of chemically active substances, namely, to sex hormones and carcinogenous hydrocarbons.

The carcinogenous hydrocarbons, as benzanthracene, benzopiren, methylcholanthrene and many of the derivatives of these polycyclic non-nitroge-

nous substances exert also a strong influence on the processes of cell and nucleus division, producing changes which are to some extent analogous to those caused by colchicine.

As early as long before Blakeslee's and Avery's work the influence of colchicine on animal tissues was tested and its strongest influence on the karyokinesis was established. For this reason it was considered as one of the strongest karyoclastic poisons.

Hence, there exists a certain similarity in the biochemical effects of colchicine, which is capable of inducing formation of polyploid chromosomal sets, of carcinogenous substances, which increase the rate of cell and nucleus divisions, and of sex hormones, when acting under certain conditions. This similarity consists in the ability of all these substances to disturb the normal process of cell and nucleus division.

Treated with colchicine (left). Treated with acenaphthene (right).

On the other hand, if we consider colchicine not as an alcoloid, but as a derivative of phenanthrene, we can easily see some common features in the chemical structure of substances of the three groups mentioned above.

Having suggested that the specific action of colchicine depends upon its having a structure of a condensed polycyclic hydrocarbon, we have concluded that some substances with similar biochemical properties can be found among other carbocyclic hydrocarbons as well. At the same time it could be suggested that a specific action on the processes of cell and nucleus division in the plant and animal tissues might be exerted by several closely related but not necessarily identical structures.

Taking it into consideration, we have included the derivatives of naphthaline in our investigation, expecting to find among them some active substances specific in their action on the cell.

The treatment of germinating seeds with colchicine produces a very strong and characteristic effect: the treated seeds give very short roots and embryos, the latter growing further mostly in width. This allows us to judge about the action on the process of cell division of the agent in question directly from the external appearance of the treated seedlings. When testing different hydrocarbons, we have noticed that the treatment of wheat seeds with acenaphthene produces an effect quite analogous to that produced by colchicine. This effect can be seen on the photograph here presented as well as from the following table:

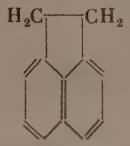
	Root length in cm	Embryo length in cm	Embryo width in cm
Control	2.5	1.5	0.1
Treated with colchicine .	0.1	0.3	0.2
Treated with acenaphthene	0.2	0.3	0.3

The cytological observations have been made by Doctor Dontcho Kostoff (see his article in the present issue), who has come to the conclusion that treatment of wheat and rye seedlings with acenaphthene induces tetraploidy and polyploidy, this effect being even stronger than that of colchicine.

The same conclusions have been drawn by Prof. Navashin, who studied, following our suggestion, the effect of acenaphthene on *Crepis capillaris* and

observed disturbances in nucleus division, causing tetraploidy and still higher degrees of polyploidy.

Acenaphthene is a derivative of naphthaline and has the following simple structure:

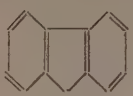


The solubility of acenaphthene in water is very low (0.003 g in 100 cm^3 of water), and nevertheless its specific action on plants is very strongly expressed.

Thus, our suggestion that the specific action of colchicine on plants, which is manifested in a strong modification of the process of cell division, must be a function of its carbocyclic structure and is related to biochemical properties of other polycyclic hydrocarbons influencing cell division, is borne out by our present investigation. Presumably a series of derivatives of napthhaline, anthracene, phenanthrene and pyrene must produce a similar effect.

The relative simplicity of the structure of acenaphthene alongside of the strong biochemical effect produced by it upon the processes of cell division facilitates its further investigation, as well as the elucidation of its specific influence.

The fluoren, a hydrocarbon having a structure rather similar to that of acenaphthene:



Fluoren

Naphthaline

has also been tested by us but proved to be wholly inactive, while naphthaline obviously suppressed the germination of seeds, its morphological effect reminding that of colchicine and acenaphthene. With further growth, however, the seedlings treated with naphthaline become different from those treated with acenaphthene (the cytological studies are not yet completed).

This shows that the presence of a five-member ring in a system of six-member ones strongly increases the biological activity of a corresponding substance, the same being true both for sex hormones and carcinogenous hydrocarbons.

Acenaphthene with its specific action on the processes of cell and nucleus division presents a great interest for the biologist. It has a number of advantages over colchicine, these being the simplicity of ist structure, lack of toxicity, much greater ease of its production, and, finally, its considerably slighter effect on plants, colchicine often causing death of treated plants.

Acenaphthene is produced on an industrial scale from coal-tar and can be synthesized from naphthaline or benzene.

In acenaphthene we have a powerful means of a radical transformation of the nature of plants from their hereditary basis, and it can probably be widely used in agriculture for producing polyploid plants. At the same time its application to animal tissues and tumours seems also to present a considerable interest. One cannot neglect the important observations of Amoroso and other authors, who have found that injection of colchicine to the animals results in the majority of cases in a complete regression and disappearance of tumours.

As the action of acenaphthene on the process of cell division is very similar to that of colchicine, and as acenaphthene at the same time possess no toxic properties, we can expect that it will also exert a corresponding action on animal tissues and, particularly, on the processes taking place in growing tumours.

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GENETICS

INFLUENCE OF ACENAPHTHENE ON THE DIVISION OF CELLS AND NUCLEI

By M. NAVASHIN

(Communicated by N. I. Vavilov, Member of the Academy, 29.III.1938)

In connection with the recent work of Blakeslee and Avery(2) on experimental production of polyploidy through treatment with colchicine, I undertook experiments on the effect of colchicine and some other substances on seeds and young seedlings. Among these substances very promising was acenaphthene which, together with some other related organic compounds, was taken for experiments following the suggestion of Prof. A. A. Shmuck who, on purely chemical grounds, arrived at the conclusion that substances producing an effect, similar to that of colchicine, should be sought for in this very group of compounds(1).

Seeds of several plant species (including soft wheat, oats and *Crepis capillaris*) were treated with acenaphthene. Owing to the very poor solubility of the substance in water, I mostly used, instead of the solution, crystals of acenaphtene which were scattered over the material placed on wet filter-paper in a Petri dish. Such a treatment produced a striking effect upon the development of seedlings. In the main it proved to be very similar to that of colchicine, in full agreement with the description given by Blakeslee and Avery (l. c.). Seeds sown on wet paper powdered with acenaphthene start germinating quite normally. In some of the experiments even stimulation was indicated. Within twenty four hours following germination, however, inhibition of growth set in, and characteristic alterations of seedlings appeared. These consisted mainly in a swelling of the hypocotyle and of the base of the rootlet. They spread later over the root-tip. The formation of root-hairs was inhibited, and within from two to three days following germination the development of the seedlings practically ceased altogether. When young (from two to three days old) seedlings were subjected to a treatment with acenaphthene, they suffered the same changes within one or two days; growth was similarly arrested and the swellings developed. A prolonged stay in acenaphthene leads to complete inhibition of growth, and the seedlings become unable of further development. Seedlings subjected to treatment with acenaphthene for two to four days recover in several days, after they have been transferred to a normal medium, and resume growing. They maintain, however, abnormal appearance (thickening and shortening which are particularly conspicuous on the plumule of the grasses). Roots which previously suffered depression begin to grow; at the apex which had lost its ability to grow and suffered deformation, a new growing point formed. Although the described pheno-

mena vary somewhat in details, their principal features are alike in different species of plants.

Cytological examination of the root-tips of the seedlings which suffered the alterations described above revealed a remarkable picture of profound and peculiar changes. These changes were the clearest in seedlings of *Crepis capillaris*, the classical object of experimental cytological studies because of its low chromosome number (2 n=6). Therefore, data reported below refer mainly to this plant.

The division figures in the meristematic cells of the root-tips were very numerous; no typical metaphases with chromosomes arranged in one plane could be seen. Nor any more or less normal anaphases or telophases could be detected. Upon closer examination it proved to be due to total lack of spindle and of a definite orientation of division. At the same time, chromosome splitting proceeded most intensely. Owing to this situation, the daughter-chromosomes formed upon separation a single group, and tetraploid sets of twelve chromosomes arose (Fig. 1). The next division proceeded in the same way, which led to formation of octoploid chromosome sets. At this stage the multiplied chromosomes were usually arranged into several groups which were

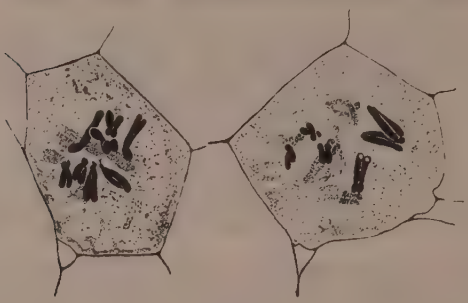

Fig. 1.

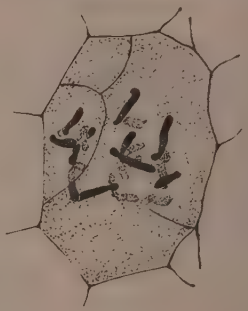

Fig. 2.

scattered upon the cells and contained most diverse chromosome-numbers (Fig. 2). Entering the period of rest, they form nuclei of various sizes. No traces of the spindle or of the phragmoplast could be detected here either. This condition was observed at some distance from the tip of the root, i. e. in a more developed region of the meristem.

During the process described fragmentation of the chromosomes sometimes took place; the fragments as usual suffered no alterations which are typical of chromosomes entering the resting stage, but remain in a condensed state assuming an irregular or more often a globular shape.

About this moment a most remarkable phenomenon takes place: t h e c e l l s a r e s u b d i v i d e d b y w a l l s. These partitions which probably arise very rapidly subdivide the cell into varied parts which are different in size and assume grotesque shapes. As a result, from two to many irregular cells are formed w i t h i n t h e c e l l - w a l l of the original cell. The chromosome numbers contained in these «daughter-cells» appear to be very different; not unfrequently cells are formed which contain no nuclei whatever. The above said is illustrated by Figs 2—3. The partitions which subdivide the cell-body consist of cellulose, but remain thinner than the wall of the original cell; their origin is not cleared up, but it is probable that several of them arise in the common cell simultaneously. The cells are fully isolated which is evidenced by the appearance of clear spaces between them,

when plasmolysis is occasionally caused by fixation. Remarkably enough these cells (which could be called «cytomeres», were not this term already applied by Waldeyer for the cytoplasmic part of the sperm) often have different appearance; for instance they differ in the density of cytoplasm. Division of nuclei contained in them may ensue at different moments. These differences most probably are caused by inequalities of chromosome-sets or possibly of conditions of nutrition. All these phenomena are not confined to any definite region of the root meristem, but all cells from dermatogene to plerome are involved, yet they are more pronounced in roomy cells of periblem and dermatogen.

It should be noted that the meristem which has been converted into such an abnormal assemblage of irregular cells containing various nuclei of different composition and even totally deprived of nuclei, maintains viability during a long period of time; at least 2—3 days following germination neither necrotic regions nor even single dying cells are found. It represents a most striking contrast to cases, when structural chromosome changes resulting in fragmentation take place (for instance, following X-raying, heat, aging, etc.).

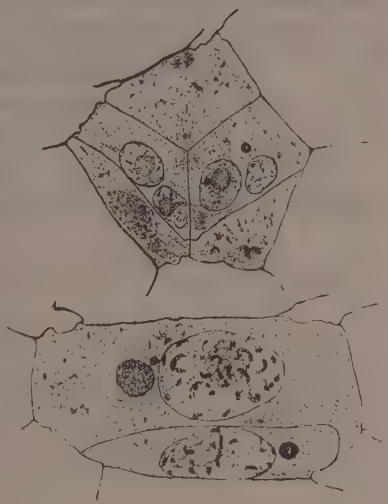

Fig. 3.

The phenomena described are different from those observed by me in the same material after treatment with colchicine. Colchicine similarly causes abnormal mitosis, producing chromosome-multiplication due to absence of the spindle. I was unable, however, to see anything similar to the extraordinary process of cell formation caused by acenaphthene. The possibility is not excluded that colchicine would produce the same effect as acenaphthene, when suitably applied (concentration, stage, etc.).

The above data which fully support the suggestion by A. A. Shmuck that acenaphthene should cause polyploidy, enable us to draw some definite conclusions. First they throw additional light upon the problem on the mechanism of the nuclear and cell division and afford a new possibility for special experiments. Lack of space does not allow detailed discussion; it should be noted, however, that there is but little doubt now about the absence of any connection between chromosome splitting and spindle formation. There is similarly no doubt that division of the cell-body is not necessarily connected with the formation of phragmoplast, although it is in some way connected with the nuclear division. It is a highly remarkable fact that each «cytomere» contains but one nucleus.

When comparing the above facts with those known for pollen-mother cells in the case of disturbed meiosis, one cannot help seeing close analogy. Irregular distribution of chromosomes followed by formation of cells which include separate groups of chromosomes is fully analogous to formation of various numbers of microspores differing in chromosome numbers contained in them. The process described must consequently result in somatic segregation, i. e. in a process, the reality of which was doubted, while its importance is self evident.

Although the majority of aberrant cells should be eliminated in the course of development, formation of chimeral organs should be expected; they should contain, aside from diploid, polyploid and heteroploid chromosome-sets, also haploid ones. The study of seedlings which recovered and started growing after having been transplanted into earth has fully confirmed this suggestion. In the cells of roots and the upper parts of the plants tetraploid, octoploid and other increased chromosome numbers were found. But, remarkably enough, a haploid sector was discovered in the very first dozen of seedlings.

The importance of the possibility of production of such a profound chromosomal variation is great, both theoretically and practically. It is sufficient to indicate that artificial production of somatic segregation and haploidy affords the means to make use of the advantages of sexual propagation also in breeding plants which have lost sexual propagation and are propagated vegetatively (for instance, the majority of varieties of potatoes). It is easy to see, that by means of somatic segregation plant-breeders will be able to obtain abundant forms which were hidden owing to influence of dominant genes. In this connection the practical importance of haploidy should be once more emphasized.

As to artificial production of polyploid forms in acenaphthene we finally acquire a sure and readily available means.

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GENETICS

IRREGULARITIES IN THE MITOSIS AND POLYPLOIDY INDUCED BY COLCHICINE AND ACENAPHTHENE

By DONTCHO KOSTOFF

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The effect of the colchicine upon the behaviour of the nucleus was shown by Dustin(1), Lits(2) and others [cf. Chadkovski(3)]. Blakeslee and Avery(4), Nebel (5) induced even polyploidy in various plants. I tested the effect of colchicine upon plant tissues. Seeds from *Triticum vulgare*, *Tr. durum*, *Tr. Timopheevi*, *Tr. monococcum*, *Tr. persicum*, *Secale cereale*, *Zea Mays*, *Canabis sativus*, *Gossypium herbaceum*, *Vicia sativa*, *Vicia Faba*, *Nicotiana* species and species hybrids, *Beta vulgaris*, etc. were soaked in 0.5% aqueous solution of colchicine over night and then transferred in Petri dishes for germination. Some were washed in running water after the treatment, others were not.

Germination of the seeds was highly suppressed, the seedlings get enormously swollen, roots remained short, but very thick. These which were washed in running water after treatment grew further somewhat better than the others.

The effect of the colchicine that was revealed by the cytological studies was: 1) enlargement of the cells and nuclei; 2) abnormal nuclei like in plant galls and in cancer; 3) multinucleation (the nuclei were in some cells equal, in others unequal); 4) increased number and occasionally increased size of the nucleoli; 5) abnormal mitosis; 6) polyploidy; 7) heteroploidy was rarely found.

The appearance of polyploid cells (tetraploid, octaploid and even of higher range) were the most striking phenomenon. In some cells 4, 5, 6 and occasionally even more nuclei were found. Sometimes micronuclei were also observed. These phenomena were found in all plants studied cytologically.

Chromosome multiplication obviously proceeds as a result of chromosome division, but failure of separation. The chromosomes appeared during the metaphase usually straight, disorderly scattered in the centre of the cell, i. e. the place usually occupied by the nucleus (or nuclei). They do not form a normal equatorial plate: this offers some difficulties in exact counts of the chromosomes, when they are several times multiplied. It seems that colchicine suppresses the activity of the forces that regulate the process of chromosome arrangements in equatorial plate and of chromosome separation. Cytology and histology of plant tissues treated with colchicine is similar to that of animal cancer, plant galls and tumours (6—9).

Considering the chemistry of the colchicine and cancerogenic agents and their effect upon the plant and animal cells, Prof. A. Shmuck proposed to examine the effect of acenaphthene upon the plant tissues.

Soaking seeds from *Triticum vulgare*, *Tr. monococcum* and *Secale cereale* in saturate aqueous solution of acenaphthene, with excess of crystals (sublimated particles), during two days and then putting them into Petri dishes, watered with the same solution, we found that the seedlings react morphologically in the same way, as they react to colchicine solution. Embryos get enormously swollen and grow very slowly, the small roots became very thick, but grow very slowly.

In studying cytologically the root tips and the embryos, the following peculiarities were noted:

Fig. 1. Wheat grains. *a*—untreated, *b* and *c*—treated with colchicine, *d*—treated with acenaphthene. Control, *a*—grain has germinated 2 days, *b*—7 days, *c*—5 days and *d*—more than 7 days.

1. Cells. The majority of the cells of the seedlings treated with acenaphthene solution are much larger than in normal seedlings.

2. Nuclei. A number of cells have two or more than two nuclei. Sometimes they are not equal in size. A very large number of cells have large and even gigantic nuclei. The nuclei are often deformed as in the cells of seedlings treated with colchicine.

Fig. 2. Nuclei from *Triticum Timopheevi*. *a*—two nuclei from two normal cells, the other from 5 cells of roots treated with colchicine.

Fig. 3. Cells with 12 chromosomes from *Tr. monococcum* treated with acenaphthene.

3. Nucleoli. In the nuclei of the treated seedlings one finds a large number of nucleoli. Large nuclei have many more and often larger nucleoli than the smaller ones.

4. Chromosome numbers: a) *Tr. vulgare* has $2n=42$. In the root tips and young leaves cells with much more than 42 chromosomes were found. Exact count was impossible for two reasons: 1) because of the abnormal position of the chromosomes during the metaphase; they usually do not get arranged in metaphase plates; 2) because of the large chromosome number.

b) *Tr. monococcum* ($2n=14$). In some cells the normal chromosome number was found, namely, 14. There were found very often cells with 28 and with more than 28 chromosomes (ca. 50, perhaps, 56). The abnormal position of the chromosomes during metaphase considerably inhibits an accurate counting of chromosome number. Sometimes, we had even difficulties in

counting the chromosomes in cells with 14 chromosomes. One somatic plate with 12 chromosomes was found.

c) *Secale cereale* (2 n=14). In the root tips of *Secale cereale* numerous metaphases were found. Cells with 14, 28 and ca. 56 chromosomes were found on the same section. In *Secale*, as in *Triticum*, the chromosomes are not arranged in normal metaphase plate, but one gets the impression that they are scattered disorderly in the centre of the cell (i. e. the position, which is usually occupied by the nucleus), often without any tendency to equatorial arrangement. The chromosomes divide, but they do not separate. Often they are arranged parallel. In some plates one finds many chromosomes equal in size and shape, lying side by side. This is also an evidence that the chromosomes divide, but do not separate, consequently a duplication takes place. Groups of diploid cells were found surrounded by tetraploid and octaploid ones and vice versa.

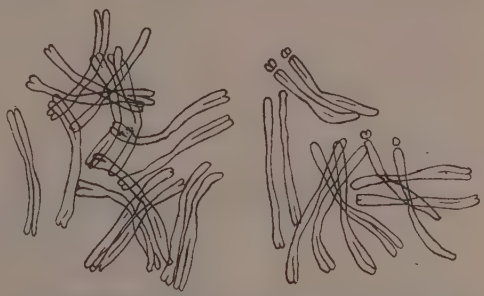

Fig. 4. Tetraploid somatic metaphase with 28 chromosomes from *Secale cereale* treated with acenaphthene. The chromosomes are purposely separated into two groups because they are too much crowded.

It should be noted that colchicine affects the plant tissues more severely than acenaphthene. Seeds treated with the latter recover more rapidly. According to the determination by A. Shmuck, acenaphthene is only 0.0028% soluble in water. Considering this, it seems more convenient for producing polyploid plants to work with saturated solution and crystals (sublimated particles) since there is no great danger that evaporation of water would lead to an increase of concentration, as it is the case when one works with colchicine. Colchicine is a strong poison. I injected 7 mg of colchicine to a rabbit and it felt sick, refusing food for two days, while ca. 25 mg of acenaphthene, injected to another rabbit in form of suspension, did not visibly affect the animal.

All these positive sides of acenaphthene are to be taken into account. It seems to me that it will be a better and more convenient agent for inducing polyploidy than colchicine.

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GENETICS

NEW DATA ON THE CHROMOSOME NUMBER IN YAK (*POEPHAGUS GRUNNIENS* L.)

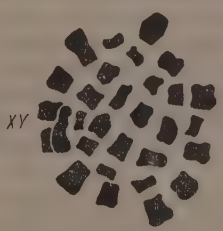
By A. I. ZUITIN

(Communicated by A. Sapehin, Member of the Ukrainian Academy, 31, I. 1938)

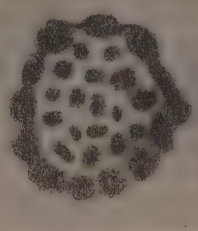
In my preceding communication on the results of investigation of the chromosomes of yak(1), aside from information on the structure and behaviour of the chromosomes, data were presented on the most probable number of the chromosomes. The diploid number 64 and the haploid number 32 were then determined.

Lack of material (derived merely from two male yaks), uncertitude as to the purity of the animals whose tests were fixed, as well as unsatisfactory

Фиг. 1.



Фиг. 2.



Фиг. 3.

results of fixation of the 1st and 2d maturation metaphases by the fixative of Allen and Hance, made it impossible to consider the published data definitive and applicable to chromosomes of pure yak.

The last year I received from J. Louss, of the Institute of Genetics of the Academy of Sciences, a new material which was fixed according to my directions after the method Champy-Minouchi at Frunze, by the end of 1935. The preferability of this material consisted not only in the method it had been fixed with, but also in the fact that it was taken from 8 males, the purity of most of which was doubtless.

Microscopic examination of the new material under application of different staining methods (haematoxylin, gentiana-violet) made it posssible to detect a series of important details which were necessary for the exact determination of the chromosome number in yak.

First, it was possible to show clearly on the new slides stained with gentiana-violet, that the chromosomes appear in the spermatogonial prophase as double threads which gradually form condensed chromosomes still possessing an equational split each. This split is often clearly expressed also when haematoxylin is applied, especially in the case of small chromosomes, some of which produce a confusing aspect of a pair of closely associated separate chromosomes.

New chromosome-counts in spermatogonial metaphases under the consideration of the above phenomenon show that the diploid number in the pure yak is in all cases 60 (Fig. 1). The chromosomes are arranged in such a manner that the largest and medium large ones form peripheric rings while the small chromosomes lie in the centre. To distinguish which of the elements correspond here to the sex-chromosomes, proves to be too difficult. An attempt of identification is, therefore, impracticable at the spermatogonial stage.

Counts of bivalents in 1st maturation metaphases in studying sections from the new material fixed with Champy-Minouchi, undoubtedly shows the haploid number to be 30 (Fig. 2). The largest bivalents are always arranged at the periphery while the rest may occupy, with regard to them, a position varying from plate to plate. Sometimes fixation makes the large chromosomes join, forming a more or less regular ring, the medium and small tetrads being within (Fig. 3).

The sex-chromosomes (XY) are usually situated at the periphery of the equatorial plate. They may closer touch each other or be slightly separated. The X-chromosome often appears as a curved elongated element, its narrow end being in touch with the Y-chromosome.

On the basis of comparative studies of the metaphases of spermatogonial divisions and of the 1st metaphase plates, the chromosome number of the pure yak thus appears to be equal to that of cattle, in which Krallinger found the diploid number 60 and the haploid 30. The data of this observer were verified by the author (unpublished).

Sterility of the hybrid males from the crosses between yak and cattle cannot be explained merely as the result of differences between the chromosome numbers of the two species, since the numbers are equal. It is possible that farther more detailed analysis of the caryotypes of the two species as well as of their hybrids, particularly a comparison of the sex-chromosomes, will throw some light upon the obscure problem of sterility of the hybrid males.

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PHYTOPATHOLOGY

A NEW METHOD FOR THE PURIFICATION OF THE TOBACCO MOSAIC VIRUS

By V. L. RISCHKOV and E. P. GROMYKO

(Communicated by A. A. Richter, Member of the Academy, 8.III.1938)

The method described in the present article is based on the adsorption of tobacco mosaic virus by benzoic acid. The fact that such adsorption actually takes place was discovered by the authors together with G. L. Einhorn.

Adsorption of tobacco mosaic virus by benzoic acid was established with the aid of the following experiment.

50 cm³ of tomato juice obtained from a sick plant, suffering from tobacco mosaic, were taken. A solution of sodium benzoate was prepared by dissolving 1 g of benzoic acid in a solution of soda ($NaHCO_3$).

The amount of soda taken was that which is sufficient for dissolving the benzoic acid, i. e. about 0.6 g per 1 g of the latter. The solution of benzoic acid is added to the tomato juice, after which benzoic acid is precipitated by a normal HCl solution. It precipitates in flakes, coloured brown by the pigment, and carries the virus down with it. The precipitate is filtered off and dissolved in a 0.1 mol solution of Na_2HPO_4. The titre of the virus in the original juice and in every fraction obtained was determined by the number of necroses per leaf of *N. glutinosa*. The figures below are averages of two or three tests. They were as follows:

	Number of necroses per leaf
Original tobacco juice, dil. 1 : 10	38.3
Adsorbed in benzoic acid and redissolved in buffer solution	95
Liquid filtered off after adsorption	11

It was found that not only benzoic acid, but the more soluble in water and possessing higher antiseptic power salicylic acid as well is able to adsorb the virus. 2.5 g of sodium salicytate in solution was added per 100 cm³ of tobacco juice, after which salicylic acid was displaced by HCl, as above. The following virus titres were obtained for the various fractions:

	Number of necroses per leaf
Tobacco juice before adsorption	27.5
Juice after adsorption	6.5
Adsorbent after redissolving	35

Having established the ability of benzoic acid to adsorb the virus without inactivating it, we resolved to utilize it for obtaining the virus in crystalline shape. The main difficulty with which one has to deal when purifying

this virus is that of eliminating pigment, since before this is done crystallization in most cases cannot be achieved. Both the method of Stanley ([3]) and that of Bowden and Pirie ([1]) are based on repeated precipitation and dissolution of virus protein. And even by this treatment one does not always succeed to free it of pigment and it is necessary to resort to the digestion of the preparation by trypsin etc. (Bowden and Pirie).

Loring and Stanley ([2]) write about these difficulties as follows: «While in the case of unpurified tobacco globulin 4—6 precipitations by $(NH_4)_2SO_4$ and 2—3 precipitations on celite suffice for obtaining a white opalescent preparation, unpurified tomato globulin demands about twice as many treatments with $(NH_4)_2SO_4$ and with celite» (p. 735). Utilizing adsoprtion on benzoic acid, we were able to work out a method which reduce several times the procedures of precipitation, adsorption and filtration and consequently saves much time. We are not as yet in a position to affirm that by our method we extract the virus from the original material as fully as this is achieved by the method of Stanley, since we did not make any comparative tests; however, the very possibility of quickly obtaining a crystalline virus preparation is of some interest.

As material for obtaining the virus of tobacco mosaic we employed the leaves and stalk of diseased tobacco or tomato plants, and it must be added that well purified preparations were obtained also from the most unfavourable—according to the literature on the subject—material, i. e. from old winter hot-house tomatoes, which are very rich in pigment.

The method itself is as follows. The original material is subjected to freezing and is twice extracted with a 0.1 mol solution of Na_2HPO_4. In individual tests we took, e. g., for 328 g of raw material 250 cm^3 of the buffer solution for each extraction. The juice obtained in this manner is filtered through filtering paper and the solution of sodium benzoate prepared in the manner described above is added to it, so as to obtain 1.5—2 g of the latter per 100 cm^3 of the juice. After a thorough mixing, normal HCl solution is added until flakes of benzoic acid begin to appear. After this the precipitate is filtered off and redissolved in 0.1 mol solution of Na_2HPO_4 avoiding its too great dilution. The resulting liquid is purified of pigments with the aid of carbolen (activated charcoal). In cases, when the liquid is not very rich in pigment, this purification is repeated twice, first with 2 p. c. and then with 1 p. c. coal. If the liquid contains more pigment, it is necessary to use 4 p. c. coal for the first treatment and 2 p. c. one for the second. Our experience teaches us that under such conditions the treatment with coal does not lead to any considerable loss of the virus. Thus, in one test we had 46 necroses per leaf of *N. glutinosa* before coal treatment, 39 necroses after treatment with 2 p. c. coal, and 43—after the second purification treatment with 1 p. c. coal. As a result of this purification we obtain a clear or slightly yellowish well opalescent liquid, from which we crystallize the virus. The crystallization itself is conducted according to the recipe of Stanley. A 5 p. c. solution of acetic acid in a semisaturated solution of ammonium sulphate is added until a pH value of about 5.5 is reached. After this we added 8 p. c. of crystalline ammonium sulphate and then, according to the amount of protein, a certain amount of a concentrated ammonium sulphate solution, no more anyhow than is necessary to obtain a 20 p. c. concentration of this salt in our liquid. The crystals begin to appear after this, and, since it is desirable that crystallization should proceed slowly, one must avoid adding too much ammonium sulphate.

In this manner crystals are obtained morphologically identical with those of Stanley. The Biuret and the Millon tests with this solution are positive. For obtaining permanent microscopic preparations a drop of the suspension of crystals in ammonium sulphate solution is spread on a

slide and first dried, then fixed with a concentrated alcoholic solution of picric acid. The remnants of picric acid and ammonium sulphate are carefully washed off under the tap. The preparation is stained by a 10 p. c. water solution of acid fuchsin and enclosed in the usual way in Canadian balsam.

The preparation obtained by us is very virulent. The crystal suspension in ammonium sulphate produces a considerable number of necroses per leaf of *N. glutinosa* when diluted 1 : 100 000. In individual tests we obtained 6 necroses per $^1/_2$ of a leaf on the average. In some cases the number of the necroses was as high as 36.5 per $^1/_2$ of a leaf, but they were not typical and we do not intend to use this material here. If we remind the reader that the above titre is that of our crystal suspension, while Stanley calculates his titres in relation to the amount of solid substance dissolved, we cannot consider the titre of our virus as lower than that of the virus of Stanley, who obtained 25.8—14.2 necroses per leaf with a 1 : 100 000 dilution (p. 315, Table 5).

The purification of the virus with the help of benzoic acid would be greatly simplified if it were possible to eliminate the benzoic acid with ether after adsorption. Experiments in this direction were arranged. The adsorbent was suspended in distilled water or in 0.1 mol solution of NaH_2PO_4 or in 1 p.c. solution of NaCl and shaken with ether. Benzoic acid carried with it almost all of the pigment and passed into the ether. An almost colourless liquid remained, however, the titre of the virus sank considerably and the liquid contained but little protein.

The method proposed by us permits different variations which do not affect essentially the final result. One can start not from the juice of the plant, but from globulin, salted out with ammonium sulphate and dissolved in 0.1 m Na_2HPO_4 and then subjected to adsorption by benzoic acid. One can also employ juice pressed out and percolated through gauze leaving out the preliminary filtration. In the method employed by us part of benzoic acid remains usually in the filtrate, but this does not essentially affect the result, since by far the greater part of the pigment and virus is carried away already by the first portions of the precipitating acid. When particularly pure preparations are desired, further purification is done with the help of recrystallization and coal treatment.

The juice of sound tomatoes as well as cabbage or onion juice contains but little protein, which may be adsorbed by benzoic acid and salted out by ammonium sulphate.

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PHYTOPATHOLOGY

MOSAIC DISEASE OF OATS

By K. S. SOUKHOV and A. M. VOVK

(Communicated by A. A. Richter, Member of the Academy, 8.III.1938)

A disease of oats known only in Siberia, under a local name difficult to translate in english*, was first described by Donchenko in 1929. The symptoms observed by her were the following: dwarfishness, shrubbiness (up to 70—80 stalks), different degree of sterility connected with flower deformity (hypertrophous ovary, spikelets transformed into vegetative sprouts). Donchenko was also the first who noted the harmfullness of this disease.

The origin of the disease remained uncleared. In 1927 Jachevsky proved it to be not communicated by seeds. In the same year Jachevsky and Gessner** stated that it is not due to fungi nor to bacteria. In 1935 Murashkinsky first classified this disease of oats among virus diseases without adducing however any new data in support to such classification.

In July and August of 1937 the authors of the present paper, guided by Prof. V. L. Rischkov, carried on a preliminary investigation of the disease on the fields of «Sibnischos» in Omsk.

There we saw the symptoms reported by Donchenko to be usually attended by a mosaic in the shape of light green stripes and spots on the leaves and leaf sheaths (Fig. 1). This symptom unknown in literature enabled us to discover the disease in plants by far earlier than it might be done from the shrubbiness and dwarfishness which manifest themselves a long time later. The time of the first appearance of mosaic since sowing was checked by us in two variants, the oats being sown on the 5 and 29 of July. In both variants the first sick plants appeared the 18th day after sowing. This isochronous manifestation of the symptom in plants under different meteorological conditions points perhaps to the regularity of the incubation period.

Having examined many of hundreds plants bearing typical symptoms of dwarfishness and flower deformity, we only very seldom did not succeed in finding the mosaic pattern which in those cases seemed to be hidden. In a number of cases, however, the mosaic was the only symptom of the disease while the number of stalks and the structure of flowers did not vary from norm. This as well as the fact that the mosaic is the first to appear on the plants when the other symptoms are not yet manifested, enable us to consider it as the most general symptom of the disease, dwarfishness and sterility

* «Sakuklivanie».
** Cited in Donchenko's paper.

being the worst forms of the latter. Another evidence for the community of the symptoms described by Donchenko and of the mosaic is their similar response to the date of sowing. Donchenko stated that late sowings are affected by the disease not so badly as the early ones. Table 1 shows our sowing on May 28 to have given a 6 times smaller number of mosaic plants compared to the sowing of May 4, the number of dwarfs having decreased five times. It may also be seen from this table that the ratio of dwarfs to the diseased full-sized plants is considerably decreased in later sowings. The latter thus exhibit not only a reduced ratio of diseased plants, but also a milder course of the morbid process.

Fig. 1. *a* — control leaf; *b* — oat leaves affected by mosaic.

The mosaic is capable of hiding itself according to meteorological conditions. Hiding is favoured by dryness or high temperature of the air. By the end of vegetation mosaic is completely hidden. A great disorder may be observed in the distribution of sick plants among the oats; they alternate with sound plants without forming separate nidi; thereby the mosaic of oats is sharply different from that of wheat.

All the varieties of *Avena sativa* are affected by the disease, as well as the species *A. strigosa* and *A. byzantina* tried by us. An agronomist of the Tulunsk agricultural test station reported (unpublished) the disease in *A. fatua* and *A. sterilis*.

A cytological investigation of the light green portions of mosaic oat leaves discovered the presence of intracellular inclusions in the shape of vacuolar corpuscles (Fig. 1) which as to their size and outward appearance were found to be similar to the inclusions reported by Mc Kinney in mosaic wheat. Without

Table 1

Affection of Oats Sown at Different Dates

Date	Total number of plants under test	Total ratio of affected plants in %	Ratio of			Ratio of dwarfs to other affected plants in %
			dwarfs in %	markedly mosaic in %	slightly mosaic in %	
May 4	843	52.7	27.0	12.0	13.5	51.2
May 28	734	29.0	6.1	2.0	20.9	21.1
July 5	520	6.3	0.57	—	5.7*	10.0

* Among plants sown on July 5 the discriminations between markedly and slightly mosaic ones have not been done.

predetermining the rôle of these corpuscles Mc Kinney supposed them to be agents of the disease or products of pathogenic secretion of the cell. We have succeeded in determining that the vacuolar corpuscles in oats are products of the cell secretion. Normal green leaves are deprived of these corpuscles. Yet in dying off leaves of sound plants when the chlorophyll is already being destroyed but the tissues still remain juicy, the vacuolar corpuscles are forming too. The same was observed in the leaves of sound wheat and barley. In this connection the inclusions of Mc Kinney's should be considered as formations linked with the pathogenic secretion of the cell and having no direct bearing on the agent of the disease. Apart from the vacuolar corpuscles we have found spindle-shaped crystals, probably of protein nature, in the epidermal cells of affected plants. Vovk recently investigated the anatomical structure of diseased plants and found their vascular system to be strongly disturbed. In dwarfs the phloem of the stalk was considerably necrosed. The necrosis is sometimes spread over the neighbouring parts of the parenchyma. In slightly affected plants in which mosaic is the main symptom of the disease, there is no necrosis of phloem or else it is but weakly developed.

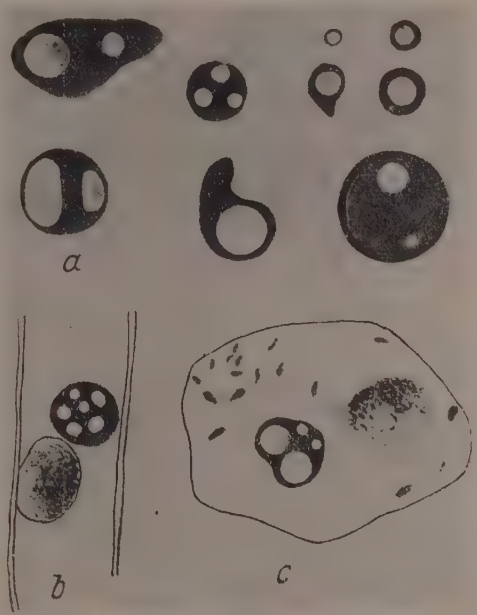

Fig. 2. *a*—various vacuolar corpuscles from the light-green portions of mosaic leaves; *b*, *c*—vacuolar corpuscles in the cells of mosaic leaf.

A chemical examination, carried out in the chemical laboratory of the Microbiological Institute of the USSR Academy of Sciences, showed the dwarfs to increase their ratio of total nitrogen as compared to control: 2.7—3.03% instead of 1.5—1.7%.

The communicability of the disease was tried by artificial infection. Above 2000 plants being inoculated all experiments gave negative results, as it may be seen from Table 2. Consequently, both mosaic and other forms of disease are not transmitted by the sap.

Table 2

Artificial Infection of Oats
(Inoculated, July 11—16; Inspected, August 22—23)

	Number of plants	Affected	Ratio of diseased plants in %
Inoculated without insulation	1982	126	6.3
Control	3875	244	6.2
Inoculated under gauze insulator	381	—	—
Control	608	—	—

Parallel experiments aimed to elucidate the part played by the soil in the communication of the disease. A 10.5 m^3 plot sown with oats was covered by means of 14 gauze insulators. The oats were sown on July 5, inspected on August 25. Not a single affected plant was found among 1911 plants covered with 13 insulators, though there were many diseased plants on the neighbouring plots. Only under the 14th insulator, covering 95 plants (4.7% of the total), five mosaic plants were found. The latter case is probably due to a disease carrier having incidentally penetrated under the insulator. In other experiments 1767 plants cultivated under insulators gave only one diseased plant. Thus, out of 3773 plants grown in fertile soil under insulators only six caught mosaic, i. e. 15% (40 times less than the average ratio of diseased plants grown without insulation). We may thus consider the protective effect of insulators beyond doubt and the disease as not transmissible through soil but having rather to be ascribed to some insect carrier, though the first observations have shown that the plant-louse and the *Thripsidae* species take no part in the transmission of the disease.

Conclusions

If the attempts at infection with sap failed, nevertheless some indirect data point to the virus nature of the oat mosaic; namely, the following:

1) Definite time (18 days) elapsing from sowing till the appearance of the disease.

2) The flowers turning green as in some other virus diseases.

3) Phloem necrosis, which is of frequent occurrence in virus diseases.

4) Inclusions in the shape of crystals and vacuolar corpuscles.

5) Mosaic typical of cereals affected by a virus disease.

6) Protective effect of insulators, which points to the insects as carriers of the disease.

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PLANT PHYSIOLOGY

NEW METHODS OF STUDYING THE BROWN SPOTTING DISEASE IN POTATO

By N. ARKHANGELSKAYA

(Communicated by A. A. Richter, Member of the Academy, 2.III.1938)

Brown spotting is a disease of potato observed in regions of sandy clayey soils, especially of soils given mineral fertilizers every year. The disease usually appears in the second half of the vegetative period (July-August), as dark brown spots on the stems of leaf petioles. The plant above the ground is gradually blackening and drying off; thus, its vegetative period is reduced, the total yield drops, as well as the value and starch content of the tubers.

The first work dealing with the disease has been that of Girenko, published in 1932. His principal conclusions are: 1) The acidity of the soil is in the first line responsible for the disease. 2) A more or less intense alkalinity curtails or completely annihilates the disease. 3) The use of fertilizers matters very much in the problem; chlorites, especially silvinite, being introduced in spring before sowing, enhanced the development of the disease greatly.

Further work in the line (carried on in the Agrochemistry Department of the Potato Institute in 1933—36) modified and deepened the statements advanced earlier.

1. Agrochemical investigation of different soil samples in a vegetative experiment have shown that the acidifying of soil, always accompanying the disease, is not the crucial point, since the brown spotting of potato, though it appears on acid soils only, is not increasing parallel with the increase of pH in the soil. Thus, if there is no disease with pH approaching neutral reaction (pH=6—7), nevertheless the following test proves the acidity of the soil to be not the only factor responsible for the disease. Three variants with diseased potato: 1) silvinite, 2) silvinite+superphosphate and 3) silvinite+superphosphate+ammonium sulphate being taken, and the figures of pH of the soil in each pot of these variants ranged in an increasing series, the pH of the pot with the most badly affected plant occupied the highest position (Table 1).

Table 1

Variants	Soils	Stage of disease	Description of the morbid states
Silvinite	4.75	III	I st.—spots only on stems
Silvinite+superphosphate . .	4.74	III	II st.—spots on petioles too
Silvinite + superphosphate + ammonium sulphate	4.35	II	III st.—strongly developed disease: leaves blackening, the whole plant wilting away

2. A study of vegetable samples from the vegetative experiment showed the ash of the leaves of the most badly affected potato to possess a least ratio of MgO content determined after the volume method of Gedroiz (Table 2).

Table 2

Variants	Per cent of MgO in an absolutely dry sample	Stage of disease	pH of soil
Without fertilizer	1.62	None	4.80
Silvinite	0.83	III	4.75
Ammonium sulphate+superphosphate	1.01	II	4.30
Ammonium sulphate+superphosphate+silvinite	0.68	III	4.35
Ammonium sulphate+superphosphate+silvinite+lime	1.42	None	5.60

From the decrease of MgO ratio in the ash of diseased plants it seemed natural to suppose that also the other components change their quantities in an affected potato plant. This supposition was evidenced by a number of analyses of leaf of diseased and sound plants, three varieties of potato having been subjected to experiment (Table 3).

In carrying on the analyses one was struck above all by the different colour of the ash: the ash of the sick plant displayed a pronounced green-blue colour (typical of ash containing Mn in excess), while the ash of the sound plant had its usual grey shade. Therefore just from the colour one was able

Table 3

Variants	Ash content	Mn, %	Sesquioxides, %	Fe, %	Al, %	MgO, %
		In an absolutely dry test portion				
Lorch sound	6.85	0.259	0.579	0.125	0.454	1.01
» diseased	7.09	0.424	1.083	0.225	0.858	0.51
Silesia sound	6.65	0.505	1.068	0.269	0.799	0.63
» diseased	7.45	0.728	2.178	0.458	1.720	0.41
Svitez sound	7.90	0.416	0.735	0.123	0.612	0.55
» diseased	11.26	1.086	3.548	0.583	2.965	0.43

to establish a greater quantity of Mn in the ash of the diseased plant. The analysis of the ash for Mn, made after Horwast's method, confirmed this supposition: the sick plant proved to possess a two times (Svitez variety 2.5 times) higher content of Mn than the sound one. Before the determination of Mn, having isolated the silicic acid, one determined the total of the sesquioxides according to the method of american chemists. Fe was determined according to Gedroiz, colorimetrically, by means of potassium thiocyanate. Al was determined from the difference. The total of sesquioxides also proved to be greater in diseased plants—two times in Lorch and Silesia, and four times in Svitez. Al and Fe determined separately display the same ratio, as to their content in sick and sound plants.

Analysis of the ash for MgO and CaO, carried on after the Gedroiz method, gave analogous results, the ratio of MgO being reduced in the diseased plants. To check the data obtained one analyzed the potato leaf taken from the

vegetative experiment, in three variants: 1) NPK, acid reaction, 2) NPK+ $+H_2SO_4$, 150 cm^3 per vessel (artificial acidifying) and 3) NPK+lime, 1.0 hydr. acidity. By the time of harvesting the brown spotting highly affected the leaves of the H_2SO_4-variant—III stage, on the leaves of the NPK-variant the I stage became more expressed, while in the variant with lime the plant remained uninjured throughout the vegetation period (Table 4).

Table 4

Variants	Mn, %	Fe, %	Al, %	Sesqui-oxides, %	MgO, %	pH, %	Stage of disease
	In an absolutely dry test portion						
NPK (ammonium sulphate + superphosphate + potassium salt)	0.360	0.196	0.420	0.616	0.62	4.28	I
NPK+H_2SO_4 . . .	0.930	0.240	0.642	0.882	0.40	4.05	III
NPK+lime	0.164	0.142	0.338	0.480	0.64	6.17	None

Curiously enough the soil in the vessels with sound plants had almost a neutral reaction, the ash of those plants showing a low ratio of Mn and sesquioxides, whereas the diseased plants were, as in the previous case, characterized by a high ratio of the above components and the soil was obviously acid. In this case too the progress of the morbid process was not parallel to the increase of acidity: the acidity of soil in vessels with badly affected plants was only a little higher compared to NPK-variant, in which the diseased plants did not pass beyond the I stage, yet the latter had a 2.5 times lower content of Mn in the leaf ash and a $1^1/_2$ lower ratio of sesquioxides.

The above analyses put beyond doubt the connection between the morbid phenomena and the accumulation of certain elements in the plant (Mn, Al, Fe). This accumulation, as shown by analysis, proceeds only in acid soils. Thus it is obvious that the liming of soil is the best means to protect the plant against brown spotting.

Foreign literature frequently dealt with the virulent effect of the above minerals on plants. Bertrand reported two maxima of Mn accumulation in plant: 1) period of plant's development—Mn is positively participating in the physiological life of the plant; 2) period of useless, perhaps harmfull, accumulation of Mn in the plant. The second period coincides with vegetative period, that is with the time, when the brown spotting is most extensively spread.

According to Brenchley, a number of investigators (Vogler, Masoni and Haschoff, Fluhrer and Haun) refer the harmful effect of Mn on the plant to sandy soils. On the other hand, many authors (Garsten, Hopkins, and others) report that an increase of the acidity of the soil accounts for the penetration of poisonous doses of Mn into the plant. The toxical doses of Fe are also reported in acid solutions by Hoffer, Uspensky and others. Some investigators, however, consider the dissolution of Fe as dependent upon the pH of the soil. Garsten, Joffe, for instance, refer the highest solubility of Fe to pH=4.2 to 4.4, the solubility of Fe is going down as the acidity sinks, but the neutral reaction (pH=7) is accompanied by a new increase in the solubility of Fe.

Some works (Johnson's, for instance) consider the toxic effect of Mn on the plant as due to depressed assimilation of Fe. Possibly, Mn in excess acts as strong acidifier and acidifies Fe transforming it into forms poisonous for the plant. This supposition should be verified by further research.

There are many works in literature dealing with toxic effect of Al on the plant; in this case, however, the question as to the accumulation of great amounts of Al in the leaf of diseased plants must be discussed apart, since the accumulation of Al was determined from the difference (indirectly), and a check of the analysis is necessary which will make safe our conclusion and suppositions.

The present investigation has established the connection between the toxic doses of Mn and sesquioxides and the brown spotting of potato: this disease is taking place only on acid soils and in case the content of MgO in the plant is reduced. The connection established between the disease and the toxic doses of Mn and sesquioxides opens new ways to inquire into the origin of brown spotting.

Further investigations have to clear up the relationship and the rôle of these elements in the morbid process: 1) are the toxic doses of Mn directly poisonous to the plant or Mn is only an agent oxidizing other elements and creator of toxic components; 2) may not the disease be put down to the break of regular relation between Fe and Mn in the soil solution due to different solubility of these elements at different pH of the soil (Gartner, Joffe, and others).

It should be pointed out in conclusion that the toxic effect of great doses of Mn is by far less investigated, compared to the stimulating influence of little doses. The same is true with respect to Fe which is known as an element unavoidable in the phenomena of photosynthesis and small doses of which are indispensable to the plant.

As the presence of great or small quantities of Mn and sesquioxides is a link in the chain of problems concerned with the mineral nutrition of plants, it would be of great importance to make out their optimal quantities with regard to each one of the plants and soils we are interested in, i. e. quantities that would ensure the maximum growth and fruiting.

As to the potato culture on sandy clayey and sandy soils, the question is of great importance for the national economy, the brown spotting of potato being a veritable scourge in the sandy clayey regions, causing a yearly detriment to the agriculture.

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PLANT PHYSIOLOGY

CRITICAL PERIODS IN MINERAL NUTRITION OF PLANTS *

By L. G. DOBROUNOF

(Communicated by A. A. Richter, Member of the Academy, 5.III.1938)

Starting from the idea of stage development due to T. D. Lyssenko, Member of the Academy, I am discussing here one of the dynamical characters of the development of plant, viz., its mineral nutrition.

The variability of this character in the development of a plant is a result both of genetic (historical) properties of the growing individual and of environment.

Here I shall discuss the fundamental critical stages of mineral nutrition.

The essential of the work** I am concerned with consists in developing the theoretical principles governing the system of mineral nutrition of plants. In doing this I start from the established disproportion in plant's requirement of different nutritive elements and ist responsiveness to mineral nutrition during the critical periods of development.

The plant's uneven requirement of mineral nutrition elements has been studied by me for 6 years. Three species of plant served for the purpose: hemp, flax and oats. In this paper I am dealing with hemp, which has been the main subject of investigation.

In the first part of the work I aimed at establishing the laws of the variability observed in the requirement of plant to absorb some definite nutritive elements at different stages of development and the modifications of its ability to satisfy this requirement ([1]).

Further we have experimentally stated the fundamental critical stages in mineral nutrition.

These stages being established, an advisable system of plant nutrition can be worked up. Such system will permit us, by applying a suitable manuring in due time, to influence the process of plant development and to control the quantity and quality of the yield.

A series of works have recently appeared, in which the authors put under investigation the problem of the critical periods in mineral nutrition of plants. In my opinion these authors err in their approach to the solution of the problem. Not only apply they unadequate methods, but also fail in grasping the essential of the problem ([2,3,4,5]).

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* The present paper is only a short summary of another work bearing the same title, presented by the author at the young scientific workers competition on the occasion of XX anniversary of the Great October Socialistic Revolution.

** The experimental part of the work was carried on in the All-Union Experimental Institute of Hemp.

My conceptions concerning the system of the mineral nutrition of plant are based upon the two following fundamental statements:

1. Different stages of the individual development of a plant vary in their quantitative and qualitative significance.

2. The effect of any factor is not the same at different stages of the development, being determined by the significance each factor (element) has of its own, and by the relation to other factors.

The critical stages in the mineral nutrition of the genetically different (6) male and female hemp plants were established under the conditions of vegetative experiment (soil-sand and water cultures), in 1935. I prefered to use a solid substratum, as the best corresponding to the natural conditions of the culture. Applying my usual methods (1), I modified the regimen of mineral nutrition of the plant by means of giving it full mineral fertilizers at different terms (Table 1).

Table 1

Height of Stem and Quantity of Fibre and Seed in Hemp Varying with the Date of Fertilizing (given in g per 10 plants and %)

Date of fertilizing (NPK)	Height of mature plants in cm		Fibre in 10 plants						Seeds in 10 plants	
			♂		♀		♂+♀			
	♂	♀	g	%	g	%	g	%	g	%
1. Before sowing . .	102.5	90.9	1.89	100	3.17	100	5.06	100	7.6	100
2. 6 days after sprouting	106.6	87.9	**2.36**	**125**	**3.55**	**112**	**5.91**	**117**	**9.8**	**130**
3. 12 days after sprouting	105.4	91.9	2.17	115	**3.58**	**113**	**5.75**	**114**	8.7	115
4. 18 days after sprouting	97.0	86.2	**2.17**	**115**	3.04	96	5.21	103	5.9	79
5. In the beginning of budding (22 days)	82.6	79.8	1.14	60	2.81	88	3.95	78	7.0	93
6. In the beginning of flowering (34 days)	52.4	60.0	0.25	13	**2.85**	**89**	3.10	61	**15.3**	**204**
7. In full bloom (44 days)	44.6	43.8	0.24	12	0.89	28	1.13	22	8.3	110
8. Without fertilizers	43.9	29.2	0.21	11	0.19	6	0.40	8	0.7	9

In all cases fertilizers were introduced in equal quantities, after one method (which secured the most rapid and complete contact between the fertilizer and root system) and by the same person.

There were three vessels in each variant.

In our experiments we took into consideration the stage of development, height of plants, general weight of the dry superterrene mass, stems, leaves, seed and fibre crop.

We shall here pay attention in preference to indices, having industrial significance (Table 1).

The table shows that: a) the time before sowing is not the best term for fertilizing; b) the largest yield of fibre is obtained in introducing the

Table 2

Indices of Vegetative and Generative Development of Female Hemp Plants as Symptoms of Rejuvenation under the Influence of Mineral Nutrition Exerted at Different Periods of Time (All Data Relating to Mature Plants)

Time of full fertilizing (NPK)	Weight of all leaves in 10 plants in g	Weight of stems in 10 plants in g	Weight of seeds in 10 plants in g	Increase of stems in height * in cm	General height of mature stems in cm	Weight of leaves in relation to stem in %	Weight of seeds in relation to stem in %	Weight of stem in relation to total dry matter in %	Weight of seeds in relation to total dry matter in %
1	2	3	4	5	6	7	8	9	10
1. Before sowing	27.6	25.9	7.6	8.5	90.1	106.7	29.0	42.4	12.3
2. 6 days after sprouting	24.6	**29.9**	9.8	7.2	87.9	81.9	32.6	46.6	15.2
3. 12 days after sprouting	28.1	**28.8**	8.7	7.4	91.9	97.7	30.1	43.9	13.2
4. 18 days after sprouting	25.1	22.9	5.9	11.5	86.2	109.3	25.9	42.5	11.0
5. In the beginning of budding (22 days)	27.7	23.3	7.0	16.9	79.8	119.0	30.0	40.1	12.0
6. In the beginning of flowering (34 days)	**37.5**	**23.0**	**15.3**	**29.8**	**60.0**	**163.0**	**66.6**	**30.4**	**20.2**
7. In full bloom (44 days)	21.2	7.5	8.3	18.9	43.8	**281.4**	**109.9**	**20.4**	**22.4**
8. Without fertilizers	1.7	1.3	0.7	2.5	29.2	129.0	49.6	36.0	17.7

fertilizer 6—12th day after sprouting**; c) the largest yield of seed corresponds to the applying of fertilizers at the outset of flowering.

In a series of other experiments the decisive rôle of azote for the yield of fibre and of azote and phosphor for the yield of seed has been established. The high efficiency of these elements as to their influence on the crop yield is confined to the above-mentioned periods of development.

These statements appear to be general and practically important. From the data of the same table we may also deduce the following conclusions bearing upon the main point of our discussion.

1. In the individual development of a plant there is a long period during which the given factor (fertilizing) is to a considerable extent exerting its influence. For this period I suggest the name «the period of the effective action of the factor on the crop of the respective industrially valuable products» (fibre, seed). In this period some difference must be discerned, as regards vegetative and generative organs.

In relation to the fibre it lasts 22—28 days in male plants from the age of 6—12 days till the outset of flowering and 32—38 days in female plants from the age of 6—12 days till complete flowering.

* The height increment is given for the period from complete flowering till ripening. The later fertilizer was applied (but still within the limits of effective action), the more lagged ripening of seed, up to 12—15 days in case of fertilizer being introduced at the beginning of flowering or in the state of full bloom.

** Under the conditions of our experiments sprouting took place the next day after sowing, which was due to the soaking of seeds in water and setting them not very deep into mellow layer of soil-sand mixture.

2. Within the limits of the above mentioned period of the effective action of the factor (in the end of this period), there exists a short critical period during which the mineral nutrition is exerting its highest influence upon the further direction and intensity of the vegetative and generative development. The critical period is a period of little duration, the deficiency of the given factor in that period (in our case, of elements of mineral nutrition) decreases the size and the quality of the industrially valuable product. It lasts in male plants 4 to 5 days, until the buds are completely formed; in female plants, 8—10 days, beginning with the outset of flowering. Therefore there is no coincidence between critical periods in different genetical units. The same is true for different factors; their critical periods may possibly not coincide in time.

3. Within the limits of the same period of the effective action of the factor (in the beginning of the period), there exists a stage when the plant is passing from the nutrition at the expense of seed materials to the thoroughly independent root nutrition. This transitional stage has been named by N. P. Krenke and the author «the stage of liberation from the influence of parent seed». In the male and female plants of hemp the duration of this stage is 4—6 days. It sets in in 6—8 days old plants. The day it sets in and the duration depend upon both internal and external conditions.

Coming back to the main subject discussed here, I would note that the so-called rejuvenation of organism is connected with the critical period of development, being influenced by the conditions of the mineral nutrition, in which decisive part is played by relative quantities of nitrogen.

From the data of Table 2 we may judge about the phenomenon of rejuvenation, as well as of the essential of the critical period.

The rejuvenation of female plants of hemp under the influence of the modified conditions of mineral nutrition at definite stages of evolution, manifests itself in a slackened pace of development, in a more intense development of the assimilative surface (column 2 and 7), in the delayed but intense growth of stems (column 5) and in the strongly increased productivity of the generative organs (column 4, 8, 10).

The essential of the critical period in plant consists either in the change of direction of vegetative and generative development, or in the displacement of the interaction zones established by N. P. Krenke by means of morphological analysis.

The practical significance of the phenomena stated ([7]) here has found its solution in a series of conclusions, verified on facts, as regards the technique of applying fertilizers for hemp, which concerned:

1) additional nutrition, largely applied according to our instructions in the farm industry;

2) the deepness of putting mineral fertilizers into the ground;

3) their relative position against the seeds when combined sowing machine will be used.

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PLANT PHYSIOLOGY

THE RÔLE OF GROWTH HORMONES IN FORM-BUILDING PROCESSES. II. YAROVIZATION AND FORMATION OF GROWTH HORMONES

By M. CH. ČAJLACHJAN and L. P. ŽDANOVA

(Communicated by A. A. Richter, Member of the Academy, 3. III. 1938)

In a previous paper (7) the writers have shown that alterations in content of growth hormones in green adult plants play no essential part with regard to photoperiodism, the acceleration of plant development proceeding in this case independently of the change in concentration of growth hormones in the meristematic tissues of the stem tops. Light regime affects directly growth hormones in plants, their contents increasing with day length.

The effect of temperature also accelerates the development of plants noticeably, this is especially conspicuous in winter cereals, which when planted in spring can produce ears in summer only on condition of being subjected for a certain period of time to the action of low temperatures. Lyssenko (1) has shown that yarovization of winter cereals by means of low temperatures proceeds successfully in seeds which started growth and, consequently, the processes which determine the transition of winter cereals to reproductive development take place in the seeds during yarovization.

Investigating the change of growth hormones concentration in the seeds which are and in those which are not passing yarovization, it would be possible to find out to what extent these changes are regular and what is their relation to yarovization process resulting in earing and flowering of winter cereals.

Cholodnyj (5,6) has recently suggested that during yarovization of seeds the accumulation of growth hormones—auxins—takes place in the cells of the embryo; this is due to the embryo nearly stopping its growth in the period of yarovization and therefore consuming very little amount of hormones. This increase in concentration of auxins leads to the acceleration of the whole further development of the plant. This idea of Cholodnyj influenced the work of Serejsky and Sloudskaya (3) who conducted experiments to determine the content of growth hormones in the seeds of winter and spring wheats undergoing yarovization during different numbers of days. They stated that the amount of growth hormones in the seeds increased, as the latter were being kept at the temperature of 0—4°. In this connection the writers point to «the morphological response» of sprouts observed by them earlier, viz. the rate of the growth and differentiation of the first leaves was considerably higher in plants which had passed yarovization, than in those which had not (2).

We conducted in the year 1935 some experiments with winter wheat Kooperatorka and *Lutescenss* 0329, whose seeds planted on the same day

were both non-yarovized ones and those subjected to yarovization during different numbers of days: 10, 20, 30, 50 and 60 days. In their habitus the yarovized sprouts differed from the untreated ones in their first leaf being noticeably shorter and bent downwards, owing, as it seemed, to epinasty. The longer germinating seed suffered low temperature, the shorter was the first leaf of the sprout. Thus, the control plants of Kooperatorka wheat had a leaf 92 mm long; the plants exposed to yarovization during 10 days, 68 mm; 20 days, 67 mm; 30 days, 49 mm; 40 days, 46 mm; 50 days, 39 mm; the respective figures for the wheat *Lutescens* 0329 were: for the controls, 98 mm; and for the yarovized sprouts, 74, 64, 38, 38 and 38 mm.

The difference in the first leaf length was so well marked that it was possible without knowing the terms of yarovization treatment to range the pots with the plants according to degree of their yarovization.

The subsequent determinations showed that yarovization affects not only the growth of leaves, but also the length of coleoptiles. The seeds of the winter wheats Kooperatorka and *Lutescens* 0329, having been subjected to yarovization after the usual method at 2—3°C during 45—60 days, were planted together with the non-yarovized germinating control seeds into damp sawdust or into glass rods in Bouchinger dishes and kept in dark. The coleoptiles were measured in age of 5—10 days. The results of measurements performed in January—March of the year 1936 are given in Table 1. The figures present average values from 20—50 measurements.

These determinations show that both coleoptiles and first leaves are considerably shorter in yarovized sprouts that in unyarovized ones. It is impossible, however, to judge on the ground of the observations made, as to what extent the change in the growth of coleoptiles and leaves is connected with the internal qualitative changes resulting in winter cereals' earing and fruiting ability.

Table 1

Length of Coleoptiles from Yarovized and Unyarovized Winter Wheats Seeds (in mm)

	Plants	Date of measurements								
		28.I	5.II	9.II	22.II	22.II	25.II	25.II	5.III	7.III
1	Kooperatorka									
	Controls	55	32			45			49	69
	Experiments . . .	33	26			33			40	57
2	*Lutescens* 0329									
	Controls			29	60	50	58	56	52	62
	Experiments . . .	—		25	47	36	47	36	46	56

The question arises whether the above changes in growth of sprouts are not due to the direct influence of yarovization conditions, i. e. low temperature and poor moisture, and do not depend on the changes taking place in embryo and stimulating the development of plant. To solve this question it was necessary to make comparative determinations for winter and spring cereals, what was done in the year 1937. For these experiments there were taken semi-winter oat *Avena byzantina* and summer oat (№ 776 of the Shatilovskaya experimental station), winter wheat Kooperatorka and summer wheat *Erythro-*

spermum 0341. Both winter and summer seeds were yarovized at the temperature 3—5° during 60 days for the wheat seeds and 40 days for the seeds of the oats; the separate batches of the oat seeds were taken for yarovization every 5 days, and those of the wheat, every 10 days. Then all the seeds were set simultaneously into the soil in earth pots, and the first leaves of the sprouts were measured. The length of the leaf in the semi-winter oat gradually decreased from 10 cm (controls) to 5 cm (yarovized during 40 days); in summer oat, from 11 cm to 3 cm respectively. The decrease of the leaf length in winter wheat was from 7 (for controls) to 2 cm (for yarovized during 60 days); in summer wheat, from 12 to 6 cm respectively. The observations of the further development of these plants revealed that the yarovization accelerated earing of the semi-winter oat by 24 days, while the yarovized plants of the summer variety eared simultaneously with the unyarovized ones (the method of yarovization being the same in both cases). The earing of the winter wheat Kooperatorka took place only if the plants underwent yarovization for the period of no less than 40 days; both the controls and other variants did not ear at all. In the case of summer wheat earing set in in the controls and yarovized (3—5°C) plants simultaneously.

Thus, the characteristic shortening of the first leaf in yarovized plants proper both to the summer and winter varieties is not connected with the process of yarovization itself, i. e. with those qualitative alterations which bring about the acceleration of the plant development.

Similar results were obtained from the determinations of the length of coleoptiles. These results are given in Table 2. The seeds were planted on November 25, 1937, and the measurements were performed on December 2, 1937.

Table 2

Length of Coleoptiles in Summer and Winter Wheats as Influenced by Yarovization (in mm)

Plants	Days of treatment						
	0	10	20	30	40	50	60
Winter wheat							
Lutescens 0329.	49±1.19	40±1.65	25±1.51	35±0.82	18±1.70	18±1.68	18±1.42
Spring wheat							
Erythrospermum 0341. .	59±1.22	53±1.78	48±1.12		52±1.66	44±1.79	36±1.26

The length of the coleoptiles in the summer as well as in the winter wheat decreases with the increase of yarovization period. Figures 1 and 2 represent the coleoptiles of the yarovized and unyarovized seeds from the winter and summer wheats.

The shortening of the first leaves, the epinasty due to uneven growth of their upper and under sides, and the inhibition of coleoptile growth—all these phenomena, which are deviations from the normal growth of plants, suggest that the same deviations could be expected in growth hormones formation on the yarovization of seeds.

Therefore special experiments were undertaken for the determination of the quantity of growth hormones in the seeds of winter and summer cereals.

There were taken again the plants of the semi-winter oat *Avena byzantina* and of the summer oat, as well as of the winter wheat Kooperatorka and of the summer wheat *Erythrospermum* 0341.

The seeds of the summer and winter forms were subjected to yarovization at the temperature 3—5°. To determine growth hormones content the

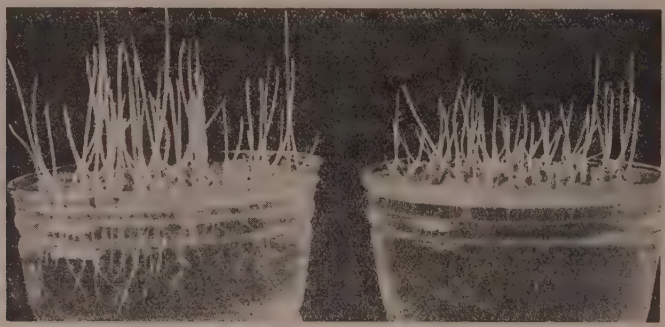

Fig. 1. Coleoptiles of winter wheat *Lutescens* 0329: left—from unyarovized seeds, right—from seeds yarovized for 60 days (photo 20. XI. 1937).

seeds (30 in number) were splintered into halves and immersed in water solution of 96% ethyl alcohol (5 cm^3 of alcohol and 5 cm^3 of water) in the same way, as it was done by Cholodnyj (4) at determination of auxins in the oat kernels. Not only the kernel but also the embryo was halved by the cut. Extracting of growth hormones from the separate halves of the seeds was con-

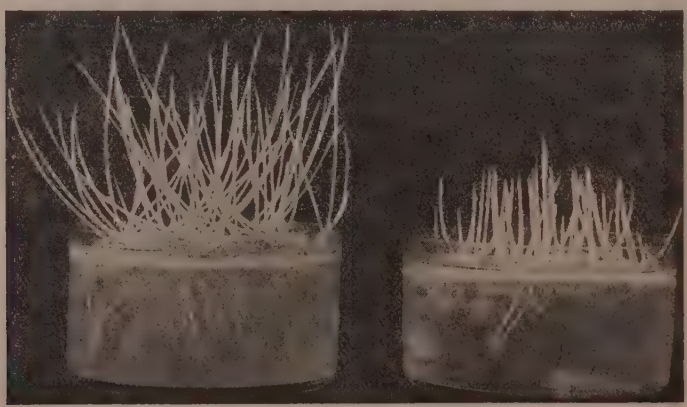

Fig. 2. Coleoptiles of summer wheat *Erythrospermum* 0341: left—from unyarovized seeds, right—from seeds yarovized for 60 days (photo 20. XI. 1937).

tinued during 24 hours, after which the solutions were poured into small china cups and evaporated in a water bath to the volume of 1 cm^3; 1 cm^3 of 12% solution of gelatine was then added. A drop of this mixture was applied to a decapitated oat coleoptile. The amount of growth hormones extracted from the seeds into alcohol and water was determined from the coleoptile curvature towards the opposite side. The decapitated coleoptiles with a drop of gela-

tine on them were kept in a moist atmosphere for 3 hours under the same conditions, as have been described in the preceding article (7).

The results of some of these determinations are given in Table 3, in which the figures represent the means from 6 measurements of coleoptile curvature in degrees.

Table 3

Effect of Yarovization on the Content of Growth Hormones in the Oat and Wheat Seeds

Plants	Date of experiment	Days of treatment							
		0	5	10	15	20	25	30	35
Semi-winter oat *Avena byzantina*	2.IV	25±0.13	10±0.74	16±3.13	15±1.42	11±0.74	19±1.81	14±1.27	15±1.45
Spring oat	25.IV	25±1.84	20±2.68	19±0.81	20±1.58	19±1.41	19±1.88	13±2.04	12±1.07
		0	10	20	30	40	50	60	
Winter wheat Kooperatorka	5.VI	19±1.24	14±0.68	11±1.60	8±1.04	10±1.22	9±1.20	7±0.95	—
Spring wheat *Erythrospermum* 0341 . .	19.VI	14±1.60	13±2.58	13±2.23	11±1.24	—	9±1.06	9±1.22	—

The quantity of growth hormones was determined as well in the embryos separated from the endosperm. No perceptible difference was observed between yarovized and non-yarovized embryos. Thus, for instance, in the experiment with *Lutescens* 0329 (June 22, 1937) the untreated embryos had 15±1.55 (in degrees of curvature) growth hormones, while those subjected to yarovization during 50 days had 12±1.49. In the experiment with the summer wheat *Erythrospermum* 0341 (August 1, 1937) the untreated embryos had 9±1.08 and those subjected to yarovization during 40 days had 7±1.07.

These data as well as the data given in Table 3 prove that, as a rule, completely yarovized seeds contain a less amount of auxins, than seeds non subjected to this treatment. The longer seeds are kept under the conditions of yarovization, the less is their content of growth hormones. The character of these alterations is identical both in summer and spring varieties, whereas the yarovization effect on subsequent development of plants is different; it stimulates the development of winter varieties, the development of summer varieties remaining unchanged. Thus, the alterations in the content of growth hormones observed in yarovized plants are brought about directly by yarovization conditions—low temperature and poor moisture—and do not determine the very process of yarovization inducing bud and flower formation.

The decrease in the amount of growth hormones in seeds, apparently, accounts for the changes in growth which may be observed in sprouts, emerged from yarovized seeds, namely: the inhibition of coleoptile growth, the shortening of the blade of first leaves and their epinasty. Consequently, the part played by the growth hormones in yarovization phenomena is restricted to the processes of plants growth.

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